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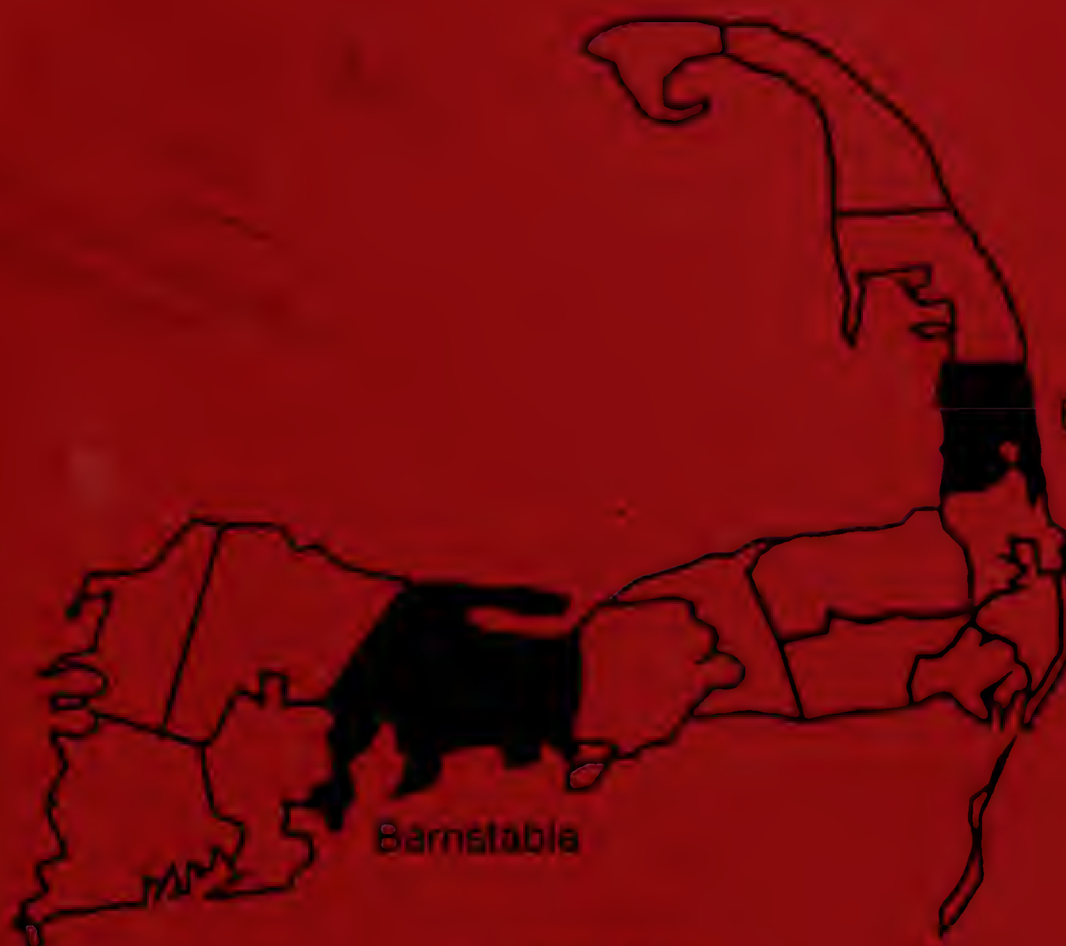
THE CAPE COD AQUIFER MANAGEMENT PROJECT (CCAMP)

Final Report



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CAPE COD PLANNING AND ECONOMIC DEVELOPMENT COMMISSION

IN COOPERATION WITH:

THE TOWN OF BARNSTABLE AND THE TOWN OF EASTHAM

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CAPE COD AQUIFER MANAGEMENT PROJECT (CCAMP)

FINAL REPORT

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION I
J.F. KENNEDY FEDERAL BUILDING, BOSTON, MASSACHUSETTS 02203-2211

December 28, 1987

To Interested Parties Regarding the Cape Cod Aquifer Management Project:

The Cape Cod Aquifer Management Project (CCAMP) was initiated in 1985 amidst high hopes and expectations from all participating agencies. Not only was it the first truly cooperative project of its kind in which a unique partnership was established between EPA Region 1 and other participating governmental agencies, but it was charged with broadly exploring a topic of increased regional concern; integrated and resource-based groundwater management among all levels of government. CCAMP was innovative in that it recognized the need to protect vulnerable areas surrounding groundwater supply wells long before Congress passed the Wellhead Protection Program as part of the 1986 Safe Drinking Water Act Amendments.

At a time when staff resources were limited, CCAMP provided an opportunity to explore a new approach to targetting environmental priorities based upon the degree of risk posed to the resource itself. The Project found certain groundwater recharge areas were more threatened than others by particular land use activities; these areas require priority attention within management programs at all levels of government. The land use study illustrates the process which may be undertaken to identify these threatening activities and set these priorities. Numerous insightful recommendations put forth by the Institutions Committee outline how these priorities should be incorporated into regulatory programs.

The Project has focused on an environmental resource for which there is presently minimal national policy guidance, no comprehensive federal regulatory programs, and few other case studies which provide direction to groundwater managers. Some of the most valuable products of CCAMP are the in-depth case studies and management tools, guidebooks and conclusions which are transferrable to other New England localities, regional agencies and other states. These will be guides to others who are attempting to set priorities within their own groundwater management programs.

The challenge of CCAMP was probably not fully understood by all project participants until the project was underway. The complexities surrounding groundwater management are numerous and challenge traditional approaches to environmental management. The success of CCAMP was to document this, provide constructive analysis and provide new tools and approaches. I believe this Final Report captures the success of the Project and outlines additional efforts to be made by all of us to implement an effective groundwater strategy.

David A. Fierra

David A. Fierra, Director
Water Management Division
EPA Region 1

The Commonwealth of Massachusetts

Executive Office of Environmental Affairs

Department of Environmental Quality Engineering

One Winter Street, Boston 02108

S. RUSSELL SYLVA
Commissioner

December 21, 1987

TO: Readers of the CCAMP Report:

With the Cape Cod Aquifer Management Project reaching completion after more then two years of cooperation between all levels of government, it is time to assess what we have done and to determine how the information generated will change the way we do business. I have no doubt there will be changes and I see them falling into the three following broad areas:

1. The partnership of federal, state, regional and local administrators and technical staff has worked so well on this project that I see this association continuing in the management of other projects in the future. This team approach has resulted in the generation of new information that has expanded the frontiers of knowledge on ground water management and will result in benefits far beyond our borders. The combination of expertise that has been put together has already spurred renewed efforts to provide more technical assistance to local officials that in turn will benefit the people of those communities.

2. The emphasis on an interdisciplinary approach to protecting the resource of ground water has sometimes been difficult for program oriented people who work with laws, regulations, policies and guidelines that focus on individual programs. I think this new way of looking at our tasks is moving us in a direction of closer cooperation and shared responsibility for ground water protection.

3. The current pressure to clean-up hazardous waste, with the costs and risks associated with these clean-ups, makes clear the necessity of doing all we can do to prevent toxics from getting into our soil, water and air in the first place. CCAMP has served as a valuable catalyst with its continued emphasis on prevention. We are moving now to looking at reduction of contaminants at the source in order to keep them out of the waste stream altogether.

I am confident that all who took part in this exciting project have learned much from the experience. I am sure we will continue to learn as we put into practice the many worthy recommendations forged by the serious work of this joint venture.

Sincerely,

S. Russell Sylva
Commissioner

ACKNOWLEDGMENTS

The editors of this report and members of the Steering Committee of the Cape Cod Aquifer Management Project (CCAMP) acknowledge with gratitude the support of former Commissioner S. Russell Sylva of the Massachusetts Department of Environmental Quality Engineering (DEQE) and David A. Fierra, Director of the Water Resources Division of the U. S. Environmental Protection Agency, Region 1, whose initial planning efforts launched this resource-based project. During the two-year tenure of this project, from August 1985 to December 1987, they not only provided the vision but also the leadership for ensuring the necessary human and financial resources within their respective agencies to complete this study. We also acknowledge with great appreciation the support provided by Carol Wood, former director of the EPA Region 1, Office of Groundwater Protection at the start up of CCAMP.

A project of this magnitude requires the help and assistance of numerous contributors. They provided much of the information needed to formulate the findings and recommendations of CCAMP. The editors are greatly indebted to the many dedicated staff at DEQE, EPA Region 1, U. S. Geological Survey, and Cape Cod Planning and Economic Development Commission who contributed as project participants, as listed on Appendix A, throughout CCAMP. We also appreciate the support of the many other agency staff, too numerous to mention, who served temporarily on one or more CCAMP committees during CCAMP's tenure. We acknowledge the important contributions of the staff of the Barnstable County Health and Environmental Department and the Massachusetts Department of Environmental Management who participated as CCAMP committee members.

We are particularly grateful for the the support received from the boards of selectman of the Towns of Barnstable and Eastham, and important efforts of the many town employees and interested citizens who volunteered their time for data gathering and committee assignments, all so crucial in seeing CCAMP through this study period. Within the Town of Barnstable, we acknowledge with gratitude the special support provided by Thomas Mullen of the Barnstable Fire District, John Kelly of the Board of Health, Russell DeConti of the Office of Planning and Development, Donald Rugg of the Centerville-Osterville Fire District, the Department of Public Works staff, the Waste Water Treatment Plant staff, and the fire chiefs in the villages of Barnstable, Hyannis, Centerville-Osterville for providing assistance and access to their records. In the Town of Eastham, we are particularly indebted to Selectman David Humphrey, Joseph Moran and Herbert Whitlock without whose efforts it would not have been possible to study aquifer protection for this community. We also greatfully acknowledge the assistance provided by the Yarmouth selectman and Board of Health.

Finally, special thanks are in order for the support received from the Massachusetts Department of Environmental Quality Engineering, the U. S. Environmental Protection Agency, the Cape Cod Planning and Economic and Development Commission and the U. S. Geological Survey. Without the resources provided by these agencies, either financial or personnel, it would not have been possible to have initiated and completed this project.

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CHAPTER 1

INTRODUCTION

1.1 Background

Cape Cod's groundwater is the sole source of water for domestic and for most commercial and industrial uses. In recognition of this and the need to initiate steps to protect the purity of this fragile resource for future generations, EPA officially designated the Cape Cod peninsula as a a Sole Source Aquifer in 1982.

Groundwater on Cape Cod has long been considered a pristine resource in abundant supply but increasing incidents of contamination of public- and private-supply wells have been occurring in recent years. The extraordinary development pressure on Cape Cod has also created additional cause for concern. Barnstable County, synonymous with Cape Cod, has been growing at the fastest rate in New England. Between 1970 and 1980, the population grew 53 percent; another 46 percent increase is expected in the winter population alone from 1980 to the year 2000. In the year 2000, the Cape Cod aquifer will be called on to provide 230,000 year-round inhabitants with 5 billion gallons of water annually and an additional 3 billion gallons during the summer, excluding commercial and other water uses. With this high level of residential growth, will come significant commercial and industrial development.

The peninsula's sandy, permeable soil and generally shallow depth to the water table make its groundwater particularly vulnerable to contamination. Further, as shown in Figure 1.1, there was concern that many of the groundwater-supply areas (or zones of contribution) which provide water for the public-supply wells, were threatened from contamination from the sanitary landfills, hazardous-waste sites, and waste-water treatment plants located within these zones. The combination of this vulnerable groundwater resource and extreme growth made the development of a comprehensive protection program urgent.

1.2 Project Need

To address these concerns and issues regarding the protection of Cape Cod's groundwater, the Cape Cod Aquifer Management Project (CCAMP) was inaugurated in August 1985. CCAMP was initiated with the goal of developing a comprehensive, resource-based approach to groundwater protection, coordinated at all levels of government. Control over the groundwater resource and its many potential contamination threats remains fragmented, with responsibilities scattered in many programs and across many levels of government. CCAMP is composed of the following participating agencies: the U. S. Environmental Protection Agency (EPA), Massachusetts Department of Environmental Quality Engineering (DEQE), Cape Cod Planning and Economic Development Commission (CCPEDC), and the U. S. Geological Survey (USGS). These agencies were concerned about these perceived inadequacies. A major concern was that groundwater resource management focused on an approach which emphasized remediation of contamination

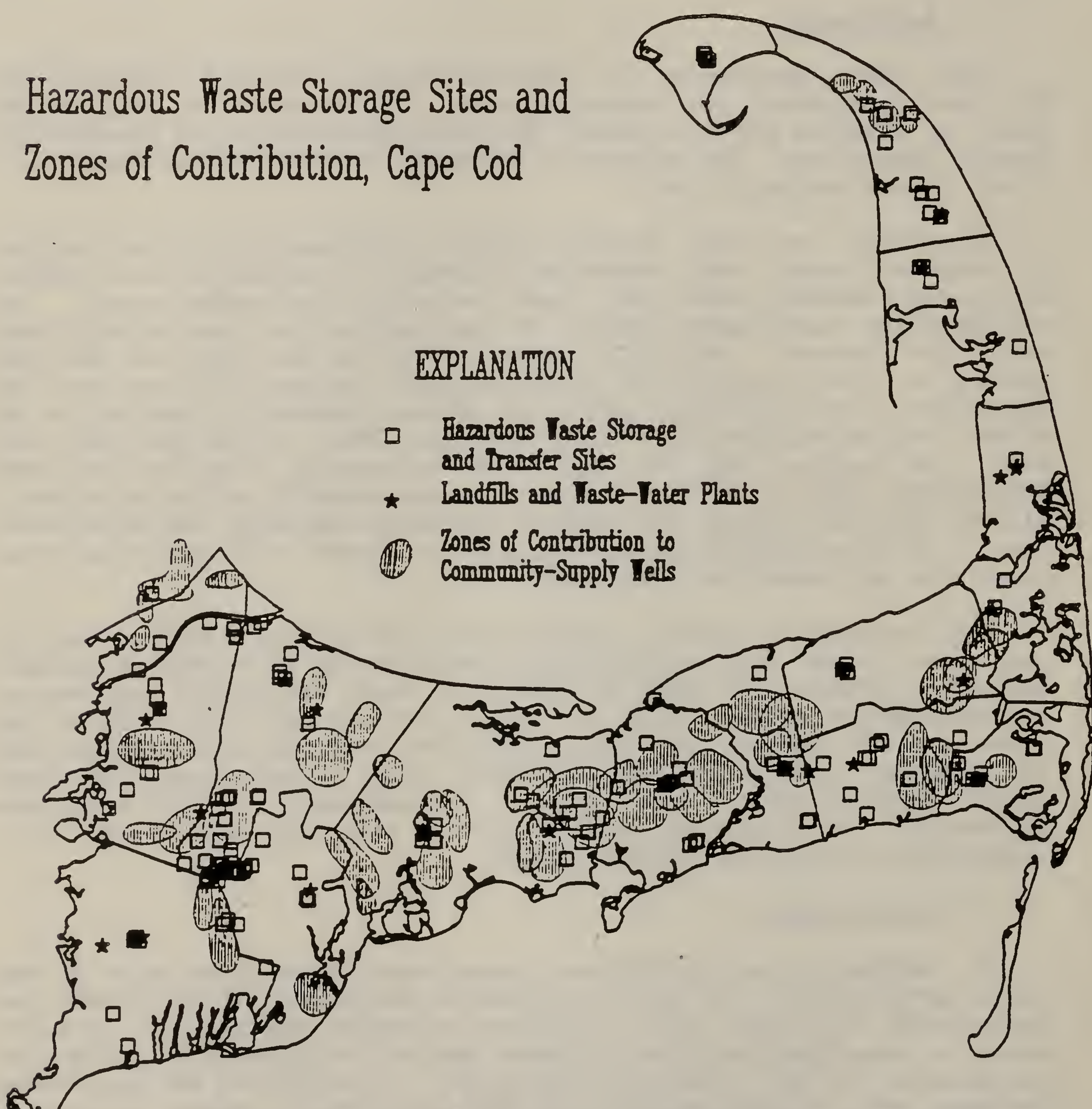


Figure 11 - Major waste storage sites and zones of contribution to community-supply wells, Cape Cod, Massachusetts

over prevention of contamination at its source. CCAMP attempted to address these concerns.

Since its inception, CCAMP's basic premise has been that groundwater protection must be based on the characteristics of the resource. This approach first required the identification of the resource(s), i.e. the area(s) that contribute recharge to a public-supply well. The next step was to determine the appropriate management strategies within that recharge area that would prevent groundwater contamination. The implementation of such strategies requires an integrated management approach, at all levels of government, with a strong scientific basis for regulatory decision making.

As a result, CCAMP was charged with the responsibility of evaluating and refining hydrogeological data and scientific methodologies for defining and protecting groundwater resource areas. These analyses are incorporated within this report along with an examination of the institutional (intergovernmental) framework for groundwater protection.

Cape Cod was chosen as the location for this prototype project because of its strong sense of environmental consciousness and its regional attributes which facilitate resource-based management. Especially important is Cape Cod's identity as a discrete region of the state, comprised of towns with common hydrology and geography, and containing a sole-source aquifer. Relative to many areas, there is an abundance of technical information on groundwater occurrence, flow and contaminant transport which has enabled officials to recognize the need for protection and to target their responses based on their knowledge of the aquifer.

The Association for the Preservation of Cape Cod spurred interest in researching Cape Cod's groundwater in the early 1970s, subsequently leading to cooperative work from 1974-1986 between USGS, DEQE, Department of Environmental Management (DEM) and CCPEDC. This cooperatively-funded work resulted in a series of reports describing the hydrogeological characteristics of the Cape Cod aquifer, a set of groundwater-flow models, a comparison of housing density and ground-water quality and a description of ground-water quality near the Falmouth landfill. Extensive work on groundwater management was also conducted by CCPEDC and EPA under the Water Quality Management Plan for Cape Cod (September, 1978), in conjunction with the Federal Clean Water Act Amendments, Section 208. Finally, in 1983, Cape Cod's regional planning agency (CCPEDC) mapped the zones of contribution for the county's public-supply wells. This made Cape Cod the first area in New England to have zones of contribution mapped regionwide for public-supply wells. CCAMP was fortunate to have this excellent information base for building and refining its data during the course of the project.

All these factors made Cape Cod a choice location for the focus of this interagency, cooperative groundwater study. The project recommendations and tools that are contained in this report, while based on the situations encountered on Cape Cod, are intended to be transferable to the rest of Massachusetts and much of New England.

1.3 Project Management.

CCAMP was managed by a steering committee composed of individuals from each of the participating agencies. This committee was charged with providing overall project direction, transmitting project findings, and presenting institutional recommendations for implementing groundwater protection strategies for all appropriate levels of government on Cape Cod.

Three working groups reported to the CCAMP Steering Committee on a regular basis on the following topics:

- Aquifer Assessment
- Data Management
- Institutions

Figure 1.2 summarizes the responsibilities for the steering committee and working groups and Appendix A provides an overview of the project organizational structure and lists all project participants. Membership in these work groups also consisted of individuals from the Massachusetts Department of Environmental Management Division of Water Resources, Boston University and the Barnstable County Health and Environment Department (BCHED). The project coordinator, the only full-time staff person for CCAMP, enhanced the communication between each work group, by serving on all three work groups .

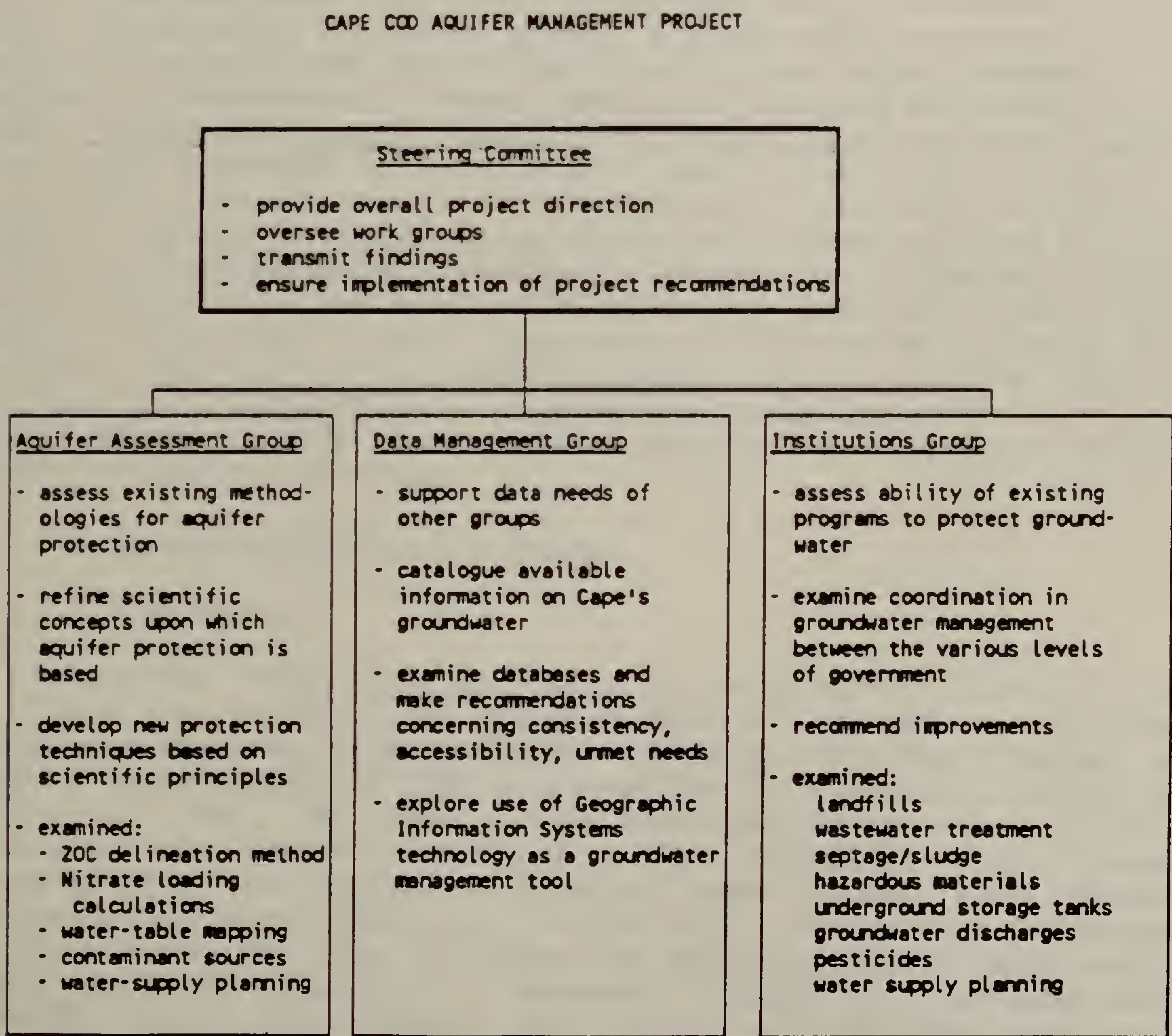


Figure 1.2 CCAMP Committee Organizational Structure

CHAPTER 2

CCAMP STUDY AREA: TOWNS OF BARNSTABLE AND EASTHAM

2.1 Background.

Although the CCAMP results are intended to have broad application in terms of revising institutional approaches to groundwater-resource management, the project focused on two Cape Cod communities.

These two towns, Eastham and Barnstable, represent the spectrum of problems facing Cape Cod communities. The two towns are divergent in terms of urban/rural characteristics, and together they typify the variety of complex management challenges facing the region. Barnstable contains a major business and population center, a waste-water treatment facility, an active industrial park and extensive public water-supply systems. It also employs a professional administration for managing environmental protection. Eastham's rural community is removed from population centers and completely dependent on private wells and on-site-disposal systems. Half its area is contained within the boundaries of the Cape Cod National Seashore. Unlike Barnstable which relies on its planning board and board of health for environmental protection, Eastham's part-time Board of Selectmen also serve as the Board of Health and the Building Inspector enforces many of the town's health regulations. The town has a largely seasonal economy, with many of the tourist-oriented services closed between September and May. Barnstable has a year-round population of 39,000 that swells to 68,000 in the peak summer season. Eastham's year-round figure is 4,700 and 17,000 during the summer.

2.2 Groundwater Protection Issues.

2.2.1 Barnstable.

Barnstable exemplifies the challenge facing much of Cape Cod - balancing land-use decisions of the past which did not emphasize groundwater-quality protection with existing and future water-supply needs. As the result of investing $100,000 in a town-wide hydrogeological study (The SEA Study) in 1985, the town is now more aware of the nature of its water resources and land-use conflicts. SEA calculated that at saturation development, the projected peak-day water demand would exceed the presently existing supply by 33 percent. Fortunately for Barnstable, options exist for the placement of additional public-supply wells that would meet the shortfall. However, a relatively slim margin of error demands that all existing and future wellhead-protection areas in Barnstable be absolutely protected.

The findings resulted in a turning point for resource management in Barnstable as the town launched a massive water-protection program. The Town Department of Planning and Development was given a substantial budget increase to implement recommendations from the study, land was acquired for water-supply protection, and the Board of Health adopted several strict new regulations designed to protect groundwater.

However, due to the extent of past inappropriate land uses such as

waste-water treatment plants, landfills, and industrial development in key water-supply areas, groundwater protection in Barnstable must continue to be an exercise in risk management (one that concurrently controls the threat of contamination from existing sources and clearly identifies and prevents the creation of new threats from high-risk sources and activities). Because of intricate interrelationships between contamination sources and groundwater flow, sophisticated methods to predict variations in zones of contribution and contaminant transport are needed. With that aim, CCAMP efforts in Barnstable focused on resolution of existing land-use and water-supply conflicts.

2.2.2 Eastham.

Eastham has several environmental threats that may result in water quantity and quality problems. These include a sanitary landfill sited in a potential water-supply area, small-lot zoning in all residential sections of town, and due to minimal staff resources, limited enforcement of their toxic and hazardous materials bylaw. The town does not have a groundwater-protection plan in place that could be used to manage the resource. However, Eastham by no means approaches the array and magnitude of groundwater protection issues confronting Barnstable, and hence has options for different siting decisions no longer available to Barnstable in terms of controlling and siting detrimental land-use activities. Eastham still has the opportunity to review zoning and subdivision control bylaws, revamp health regulations and develop a groundwater protection plan. With this in mind, CCAMP concentrated on the type of technical assistance necessary for such a town to better understand its environmental conditions so that practical groundwater protection goals can be met.

2.3 Hydrogeology

The subsurface geology of Barnstable and Eastham, like much of Cape Cod consists of glacial sediments which were deposited at the end of the last period of continental glaciation in New England. The predominant features of the Cape Cod peninsula are glacially derived moraines and outwash plains (Figure 2.1). Both morainal deposits and outwash deposits can sustain large quanities of water for public supply. Unconsolidated beach and dune deposits also contain fresh water, but because of their proximity to the ocean and small areal extent are not used for public-water supply. The crystalline bedrock underlying the glacial sediments is also poorly transmissive and has not been used as a source of water (LeBlanc et al., 1987).

The glacial outwash deposits provide water for most of the Cape's 118 public-water supplies and 31,100 private wells (Janik, 1987). The Cape's

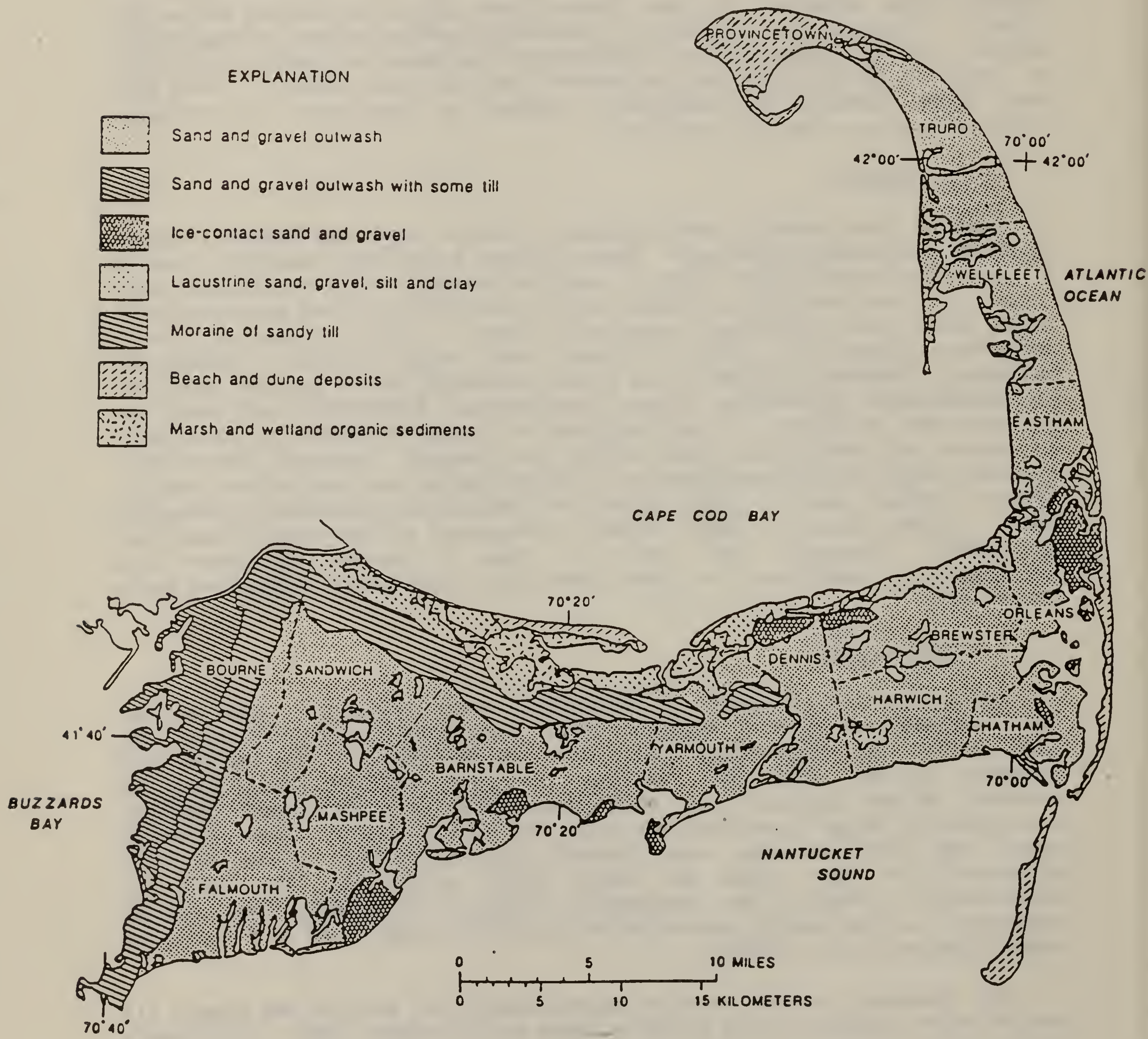


Figure 2.1 Hydrogeologic Units of Cape Cod (adapted by CCAMP from LeBlanc et. al. 1986, Fig.3)

aquifer is among the most permeable in New England, yielding large quantities of naturally high quality water. The term aquifer, therefore, is used to define those underground formations that contains sufficient saturated permeable material to yield significant quantitites of water to wells. Yet the same highly permeable sands and gravels which provide an excellent medium for withdrawing large quantities of water, create an aquifer that is extremely susceptible to contamination. Sandy soils are low in organic content and have a poor capacity for attenuating contaminants by sorption and ion exchange. In addition, the depth to the water table for a major portion of the Cape is generally quite shallow so contaminants do not have far to travel before they reach groundwater.

The aquifers of Barnstable and Eastham are generally unconfined; their upper boundary is the water table, except in local areas in which clay and silt confine the sand and gravel. The lower boundary of the aquifer underlying Barnstable consists of fine grained lake deposits and bedrock formations (Figure 2.1, 2.2). The lower boundary of the Eastham fresh-water aquifer is the fresh-water/salt-water interface, which lies at a depth of about 460 feet below land surface at the center of the aquifer as revealed by USGS test drilling in October, 1987. Groundwater in Eastham and Barnstable is found in two of six fresh-water lenses which together comprise the Cape Cod aquifer (LeBlanc et al., 1986) (Figure 2.3).

In Barnstable, glacial lake sediment is thought to underlie most of the outwash plain, and may have been deposited in a lake which extended from the retreating edge of the glacier to Martha's Vineyard and Nantucket (Oldale, 1974a). These glacial sediments are underlain by much older consolidated rocks (Oldale, 1974a, 1974b).

Eastham is underlain by about 200 feet of sand and gravel outwash deposits that were formed by meltwater streams from the retreating continental glacier, which was located to the east of Cape Cod. The Eastham outwash plain deposits are underlain by approximately 300 feet of fine-grained lake deposits of silt and clay which rest on crystalline granite as revealed by USGS test drilling completed in October of 1987 (Barlow, 1988 personal communication). The shores of Eastham and Barnstable are bordered in most locations by beach, dune, salt marsh and swamp deposits of post-glacial age.

The general direction of groundwater flow in the aquifers of Eastham and Barnstable, as shown in Figure 2.3, is from the central areas of the peninsula to bays, marshes, Nantucket Sound, Cape Cod Bay and the Atlantic Ocean, which surround Cape Cod. Many of Cape Cod's ponds are in hydraulic contact with the surrounding aquifers, with their water-level elevations being similar to those of the regional water table. The ponds can be areas of both groundwater discharge and groundwater recharge, depending upon the direction of groundwater flow in the area.

Precipitation is the sole source of recharge on Cape Cod. Average annual precipitation on the peninsula ranges from 40 inches per year on the Outer Cape to 47 inches per year on the Inner Cape. The amount of precipitation which does not run off or is not returned to the atmosphere

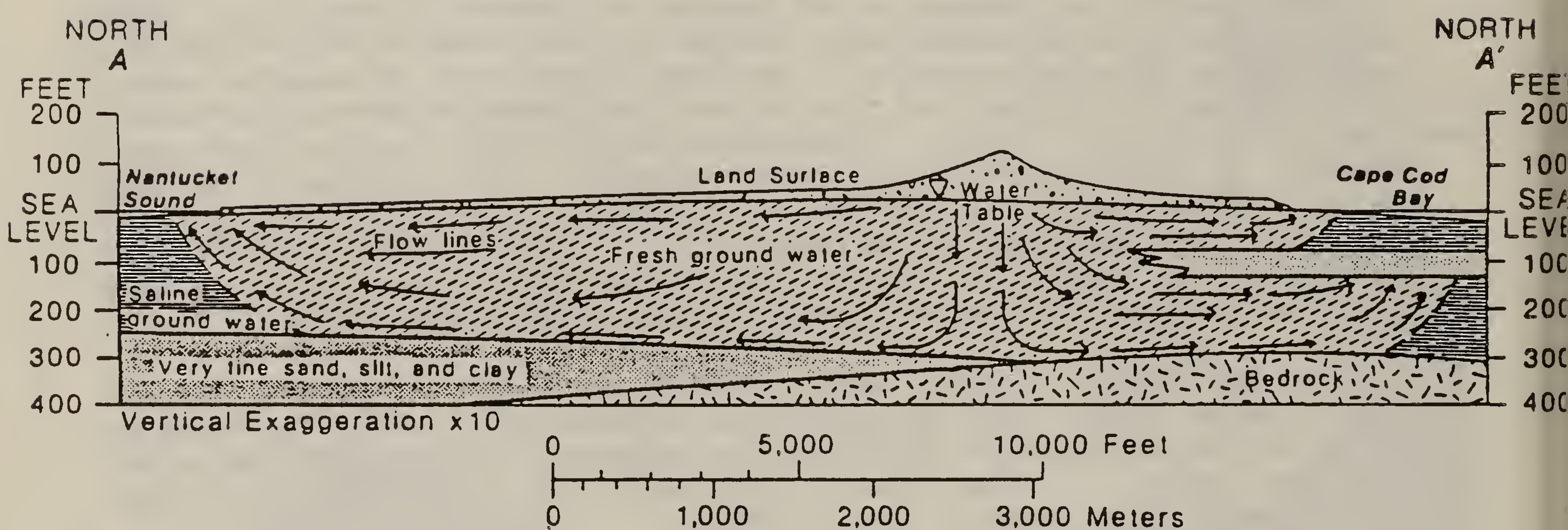


Figure 2.2 Section Through Barnstable-Yarmouth Area. Representative of Inner and Mid-Cape Freshwater Lens Truncated by Bedrock and Fine-Grained Sediments. Silt and Clay Cinfining Beds along Cape Cod Bay Displace the Freshwater-Saltwater Boundary offshore (taken from LeBlanc et. al., 1986).

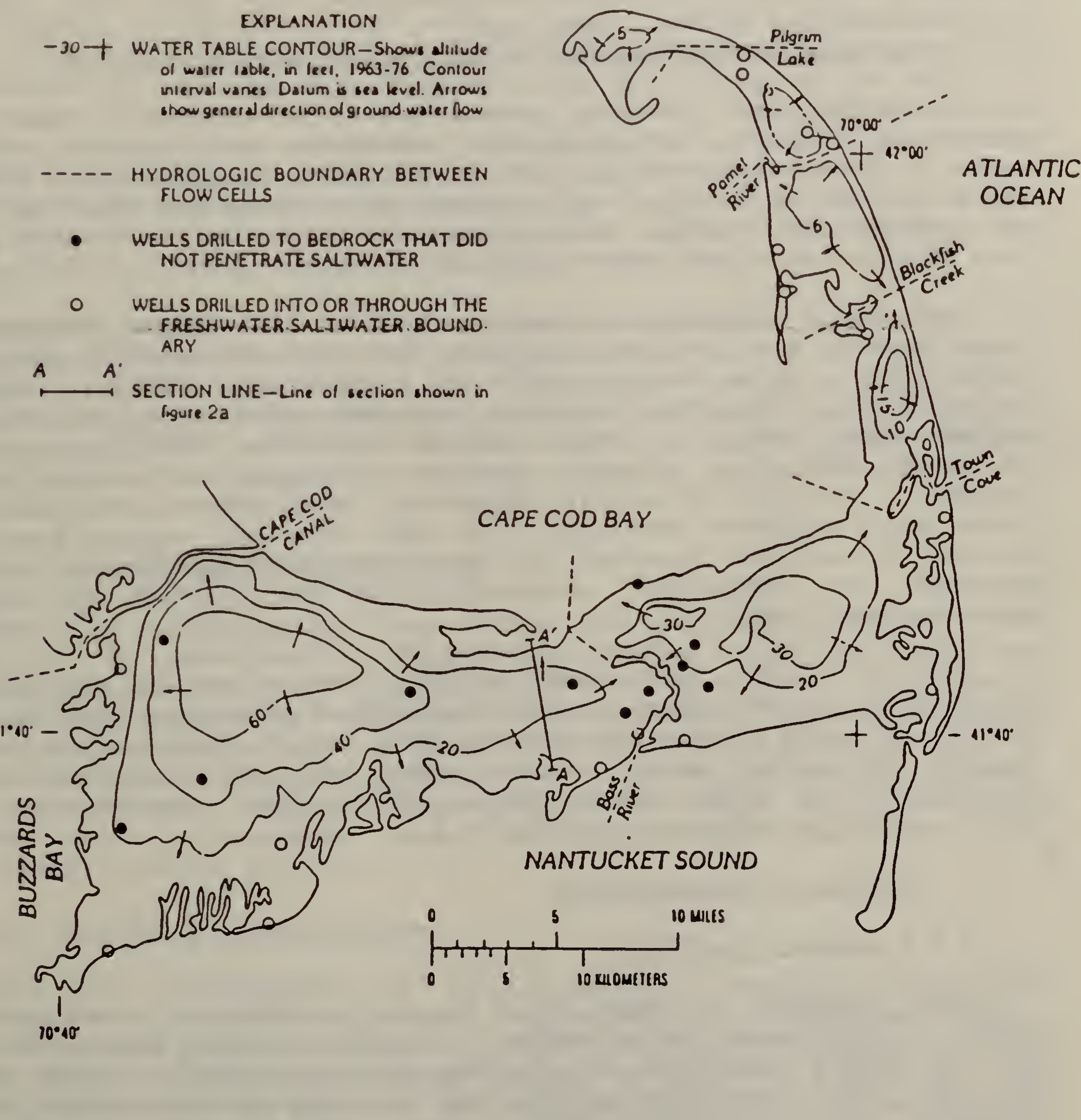


Figure 2.3 Six Groundwater Flow Cells and General Directions of Flow (taken from LeBlanc et. al., 1986).

by evapotranspiration and is available to recharge the aquifer has been estimated to range from 11 inches per year in Truro to 21 inches per year in both Truro and Falmouth (LeBlanc, 1984; Delaney and Cotton, 1972; Magnusen and Strahler, 1972; and Guswa and LeBlanc, 1985). Recharge to the groundwater also includes return flow from the septic systems and the leaching beds of wastewater treatment plants.

2.4 Groundwater Problems Facing Cape Cod: A General Overview.

Barnstable and Eastham served as the specific study areas, particularly during hydrogeological assessment and land-use inventory tasks. Cape Cod as a whole, however, served as the generalized focus for an evaluation of institutional responses to categories of existing sources of contamination. Thus, it is appropriate to provide the following overview of Cape Cod's groundwater problems.

Cape Cod's groundwater quality problems stem from a combination of rapid growth and land-use planning that did not consider groundwater protection. As a result, public and private water supplies, ponds, and wetland and estuarine resources are threatened by a multitude of contamination sources. These include: sanitary landfills, wastewater treatment facilities, leaking underground storage tanks, septage pits and lagoons, on-site wastewater disposal, fertilizers, pesticides, and toxic and hazardous materials. The Cape has not escaped some of the adverse situations presented by heavy industrial development, including disposal of industrial wastewater and the creation of intensive hazardous-waste dumps.

Prior to 1970, little hydrogeological information was available upon which land-use decisions emphasizing wellhead protection could be based. Development thus proceeded in a manner that largely did not consider water quality protection needs. Across Cape Cod, the delineated zones of contribution to public-supply wells unfortunately contain many of the major sources of pollution (See Figure 1.1).

2.5 Sources of Contamination

2.5.1 Sanitary Landfills

Many landfills on Cape Cod, in use or abandoned, have generated a plume of groundwater contamination. Groundwater quality around two-thirds of the active landfills on the Cape has been evaluated to some degree. All the tests have revealed compounds typically associated with landfill leachate such as volatile organics, phenols, sulfate, iron, manganese, and other metals. Some towns, such as Falmouth, Orleans and Yarmouth, have mapped their landfill plumes based on the chemical composition of water samples collected from monitoring wells over a period of time. To a great extent, landfills are often located in groundwater recharge areas. As a result, Cape Cod landfills have contaminated significant portions of the aquifer that otherwise would be available for water-supply development by towns. In addition to the threat posed to public-supply wells, private wells are also vulnerable to contamination from landfill plumes.

2.5.2 Underground Storage Tanks

Cape Cod, like many other areas with important groundwater resources is endangered by underground fuel storage tanks. CCPEDC estimates approximately 4550 USTs Capewide (Janik, 1987). As more and more of these tanks are tested, for ensuring that releases to the environment do not occur, it is becoming clear that many have not been pressure tested and thus are or have the potential to contaminate groundwater. As an example of the high potential these tanks pose for environmental contamination, 19 of the 40 confirmed hazardous-waste sites on Cape Cod, as listed by DEQE in October 1987, were the result of petroleum-product contamination, usually from leaking USTs or piping (Commonwealth of Mass. DEQE, 1987).

Numerous leaking USTs have been discovered Capewide largely from the widespread implementation of the Barnstable County Health and Environment Department (BCHED) regulations requiring routine testing of aging tanks. The most publicized UST release on Cape Cod which threatened nearby public-supply wells occurred in 1977 when 3,000 gallons of gasoline leaked from a tank at a gas station in Truro. To date, aquifer remediation in Truro has cost more than $5 million dollars.

2.5.3 Waste-Water Treatment Plants

Plumes of contamination from large secondary waste water treatment plants at the Massachusetts Military Reservation and in Barnstable have degraded groundwater quality. These plumes have been documented to contain concentrations of nitrogen, BOD, synthetic organic compounds, metals and detergents well in excess of federal and state drinking water standards and have rendered substantial portions of the aquifer unusable. These contaminants threaten downgradient public-supply wells, and in one instance these contaminants caused the closure and abandonment of a public-supply well in Falmouth.

2.5.4 Septage Pits and Lagoons

Each year, approximately 64 million gallons of septage are generated on Cape Cod, 22 million gallons from commercial establishments and 42 million gallons from residences. Over 90 percent is disposed in open, unlined pits or lagoons frequently located at each town's landfill. Only Chatham, Barnstable and Falmouth have treatment plants that accept septage from haulers. While other communities such as Orleans and Harwich are pursuing the lengthy process of planning and constructing waste water and septage-treatment facilities, human-waste disposal continues to be concentrated in specific areas, creating plumes of contamination which exacerbate existing plumes from landfilling operations. Because septage is dewatered waste water, its concentration of contaminants is much greater than the waste water which flows through sewer lines. These plumes are

characterized by their high biological- and chemical-oxygen demand, high concentration of pathogens and chemical contaminants such as metals, nitrogen, phosphorus, sodium and volatile organic hydrocarbons. They therefore have the potential to degrade groundwater quality to both private- and public-supply wells.

2.5.5 On-Site Wastewater Disposal

Over 90 percent of the homes on Cape Cod use on-site subsurface systems for disposal of wastewater (CCPEDC, 1978; Gallagher and Nickerson, 1986). Until 1977 when Massachusetts adopted its minimum requirements for the installation of on-site-disposal systems (Title 5), homes on Cape Cod were equipped only with cesspools. These systems provide no separation or treatment of effluent. While septic systems are a technological improvement, in terms of siting and design, the only significant improvement with respect to groundwater quality are bacterial and viral filtration. Additional pollutants of concern that are not removed are nitrogen species and synthetic organic hydrocarbons. Numerous public water-supply test results show a distinct correlation between housing density and nitrogen (nitrate) concentration in the well water.

2.5.6 Fertilizer Use

Nitrogen loading to groundwater from fertilizer application is an additional significant source of groundwater contamination. While leaching rates vary depending on a host of site-specific environmental factors and on nitrogen application rates to crops and turf, the average has been estimated at 1.8 pounds /year/1000 square feet of fertilized area (CCPEDC, 1978). Depending on lawn size, leaching from fertilizer application can be a significant factor in contributing nitrogen to groundwater. The recent increase in commercial lawn care services indicates that a substantial number of Cape Cod residents actively maintain their lawns with fertilizer.

2.5.7 Pesticides

Pesticide contamination of groundwater resources remains largely uncharacterized on Cape Cod. While limited testing of some public- and private-supply wells, as well as an EPA/CCPEDC study of groundwater quality beneath Cape Cod golf courses, have not identified significant concentrations of pesticides, a data gap exists with respect to this potential source of groundwater-quality degradation. Geologic and environmental conditions on Cape Cod indicate the area is conducive to pesticide leaching. A relatively high rate of recharge, combined with sandy soils, shallow depths to water table and localized spots of elevated nitrate-nitrogen in groundwater put the peninsula in a vulnerable category.

Fortunately, intensive agricultural practices with liberal pesticide applications do not predominate on Cape Cod. A large number of commercial applications are prevalent, however, including lawn care, small-scale-agricultural operations and utility right-of-way maintenance.

In order to quantify the threat that pesticide application poses to groundwater quality on Cape Cod, a program of random sampling of private drinking water wells, and monitoring wells is needed.

2.5.8 <u>Toxic and Hazardous Materials</u>

Toxic and hazardous materials contamination of groundwater is one of the most serious problems confronting Cape Cod. Even minute concentrations (a few parts per billion) of synthetic organic compounds can render a water supply non-potable.

New analytical data suggest that volatile organic compounds (VOCs) in groundwater pose a much more significant contamination problem than was previously believed. Recent testing of shallow private wells around selected Cape Cod landfills and in other areas indicates that VOCs may present an imminent health hazard to residents. It should be noted that many of these VOCs as well as other toxic and hazardous materials, which are known or suspected carcinogens, are frequently used full strength or as a constitutent in products for a number of land-use activities (refer to CCAMP Guide to Contamination Sources for Wellhead Protection) for a wide variety of commercial and industrial uses and in numerous household products. Thus, the potential for groundwater contamination from these materials will continue to increase as Cape Cod's business and residential populations expand and as long as there are no safe substitutes for these toxic and hazardous materials. Many businesses that use hazardous materials in significant quantities do not have the appropriate knowledge concerning their safe use, storage and disposal. Similarly, homeowners are also capable of using significant quantities of hazardous materials, such as septic-tank-cleaning solvents, degreasers, and paint thinners as part of special work projects that can also threaten groundwater quality from thier activities.

2.5.9 <u>Road Salt</u>

Application of road-deicing salt during winter months is an identifiable cause of groundwater degradation. The Massachusetts Department of Public Works typically applies 300 pounds of salt per lane mile during each storm. The salt eventually washes off the road. Certain public wells and numerous private wells near highways on Cape Cod show elevated sodium levels and one well has been closed due to sodium contamination from a nearby highway.

CHAPTER 3

THE RESOURCE-BASED APPROACH

Groundwater is very likely our most threatened resource and yet it is not receiving adequate protection or the overall management attention it demands. Programs at the federal, state and local levels of government designed to protect groundwater tend to focus on individual sources of potential contamination, rather than on the resource itself. While controlling pollution at the source is still important, regulatory programs must never lose sight of the resource that is being protected as new programs are being designed to meet that goal. Rather than attempting to control all sources on an equal basis (no matter what contaminants are involved, or where the land-use activity is located) regulatory programs need to differentiate among the potential contamination sources and their relative threat to the protected resource.

Historically, water-quality protection in the United States began with the "dilution is the solution to pollution" philosophy. This concept, however, does not work well in its application to groundwater because once contaminants mix with the groundwater, they are difficult to locate, monitor, and recover. Until the source of contamination is stopped, contaminants continue to mix with groundwater and move away from their point of entry in the direction of groundwater flow.

The "contaminate and remediate" approach to groundwater management followed. There were few no regulatory activities focusing on prevention of contamination at the source through land-use controls. Regulatory efforts were limited to monitoring programs and construction standards for land-disposal sites and clean-up activities.

In the early to mid-seventies, the relationship between land use and groundwater quality and the value of prevention as opposed to remediation began to be recognized. However, the understanding of what prevention might involve was still undeveloped. Because it was believed that aquifer material was capable of cleansing groundwater over short distances, prevention was focused on bacterial contamination and easily protected by the 400 feet radius around public-supply wells.

As hydrologists tracked contaminants to sources more distant than the 400 foot protection radius to public-supply wells, water management officials began to investigate the need to protect entire aquifers or watershed basins. However, where this ambitious approach was attempted, it soon proved both economically and politically infeasible.

In searching for ways to streamline and reduce the process for identifying areas in need of intensive protection, hydrologists refined hydrologic concepts for identifying the aquifer areas that directly supply a public-water-supply well. These concepts led to the identification of the "zone of contribution" to pumping wells. The approaches used for defining zones of contributions under various types of hydrogeologic conditions include both analytical tools and computer models. Today,

computer models are also used to simulate complex hydrogeological conditions. The use of the term "zone of contribution" is synonymous with the terms "wellhead protection area" (federal term) and "Zone II area" (the term used by Massachusetts) and all are used alternately throughout this report.

Though Zone IIs are simpler to protect than entire aquifers or watershed basins, due to their confined area, the protection of ZOCs are not without hydrogeological complexities, and political and economic problems. For example, several hydrogeological assumptions must be made to delineate Zone II boundaries. As an result, Zone II boundaries are not permanently fixed but vary in size and shape, depending on hydrogeological conditions and pumping stress. Another concern is that zones may overlap the political boundaries of one or more towns, thus placing one town's ZOC at risk from contamination by sources of contamination in another town.

Planning techniques that focus on the prevention of certain land uses within Zone IIs, are still highly experimental, but they are developing rapidly. Promising innovative measures are emerging, such as land-use-planning models that indicate if development will result in an overload of a certain contaminant. Also, existing land uses within zones of contribution can be intensively regulated to prevent contamination. Prevention is premised on determinations of the level of risk that is acceptable, i.e. the levels of a contaminant that will be tolerated and those that are considered excessive in relation human health.

Different types of protective measures are appropriate for different potential sources of contamination. For example, it may be sufficient to limit the density of certain land uses, while prohibitions may be required for others. In the same way, certain contaminants are more mobile than others and the protection zone size must be gauged accordingly.

The resource-based approach, used during CCAMP, is an attempt to both refine and advance the basic prevention-oriented philosophy. This approach features the following components:

1. Thorough characterization of the aquifer system so that the zone of contribution for the public-supply well can be delineated as accurately as possible.

2. Comprehensive inventory of all potential sources of contamination located within the zone of contribution.

3. Assessment of the federal, state, and local controls in place for the regulation of all existing sources.

4. A strategy for protecting the well based upon relative risk from individual sources, cumulative impacts from existing sources, and possible future problems from potential land uses.

CCAMP's goal was to facilitate the implementation of the resource-based approach on Cape Cod through the development of management tools and the promulgation of scientific and institutional recommendations. These tools and recommendations were directed at local, state and federal agencies and intended to change the way government, in general, conducts its groundwater protection programs.

CHAPTER 4

THE TECHNICAL BASIS FOR GROUNDWATER PROTECTION

4.1 Introduction

Sound resource-based groundwater management policies must rely on a firm technical basis. This includes an understanding of the resource to be protected, and of the many potential sources of contamination that threaten it. This requires information about the resource, scientific knowledge for interpreting that information, and a reliable data base pulling together many different types of information from all levels of government. These preconditions are seldom fully attained, yet groundwater management must be undertaken. This chapter presents CCAMP's findings on these decision-making "preconditions" - the technical basis on which groundwater management rests. The findings of the Aquifer Assessment Committee will be presented first, followed by those of the Data Management Committee in Chapter 5.

4.2 Aquifer Assessment Committee Findings

CAMP's Aquifer Assessment Committee, assembled to ensure that groundwater management programs are based on sound technical information, was a multidisciplinary group of hydrologists, geologists, chemists, engineers, and planners from various federal, state, regional and local agencies. The first step taken by this diverse group was to familiarize all members with the available knowledge and programs relating to the Cape's groundwater and potential sources of contamination. The committee evaluated reports and invited guest speakers to describe their research or the programs they managed.

This examination of the Cape's aquifer and the threats to it led the Committee to focus its efforts on the characterization and protection of the groundwater resource. The committee selected the following issues for examination which are summarized in this chapter:

- water-table mapping
- observation well selection
- wellhead-protection area delineation methodologies
- nitrate-nitrogen loading in wellhead-protection areas
- contaminant sources and the behavior and fate of contaminants in groundwater

Appendix B summarizes a number of Aquifer Assessment Committee recommendations relating to: (1) methods of data reduction (for wellhead-protection area delineation); (2) delineation of wellhead-protection areas; (3) DEQE's technical capabilities; and (4) zone of transition (fresh water/salt water interface) monitoring.

4.2 Characterization of the Resource

4.2.1 Water-Table Mapping

A good understanding of the water levels in an aquifer is a prerequisite for most groundwater studies, including the delineation of the recharge area or zone of contribution to a public-supply well. This will be described in more detail later in this chapter. An accurate water-table map with appropriate contour intervals is essential for investigating contaminated sites and in deciding where to locate a variety of land uses, including public-supply wells, landfills, sewage treatment plants, industrial zones, even septic systems. Understanding groundwater flow, which can be inferred from groundwater levels, is the first step in resource-based groundwater management.

The Aquifer Assessment Committee decided to examine existing water level observation points and to refine, where possible, the previous water-table map for Cape Cod produced in 1977 by the USGS. The group's intent was to demonstrate how a refined water-table map might be developed without drilling new wells and to develop a methodology for selecting existing wells that should be measured to refine the existing water-table map. In some cases, the USGS mapped contour intervals of ten feet in the Barnstable area did not provide the high degree of resolution needed for Zone II determinations or site specific contaminant investigations. The committee explored the possibility of refining this map utilizing additional existing data available from observation wells.

4.2.2 Observation-Well Inventory

The Data Management Group conducted an extensive inventory of observation wells that had been drilled by consultants, federal, state, and local agencies and village water districts for the Town of Barnstable. The first task was to thoroughly review the available geological and engineering studies at the local boards of health, conservation commissions, planning boards, water suppliers, consulting firms, the Massachusetts Department of Environmental Quality Engineering, the Department of Environmental Management's Water Resources Division, the US Geological Survey and the EPA.

Copies of drilling and soil logs were obtained whenever possible; reports or other files were also used. Relevant information was copied onto worksheets (Figure 4.1) to standardize and streamline the information collection process. Each well was mapped onto a USGS topographic map and identified by a unique number.

The inventory identified 215 wells in the eastern half of Barnstable. The Aquifer Assessment Committee then screened these wells for potential selection for water level measurement. CCAMP criteria for well selection included location, ownership, access, well construction, elevation relative to mean sea level, well depth and screened interval (a screen at or near the water table was desired). The initial 215 were narrowed down to fewer than 100 wells and these were all field checked to ensure accessibility. During this initial field check, CCAMP also recommends a slug test to test each well's responsiveness to actual water-table conditions. An array of 71 wells and seven ponds was finally selected to create a uniform geographic distribution of measuring points.

The inventory was then used to prepare a water-table contour map. The selected measuring points (measured on May 11-13, 1987) provided an examination of water-table conditions under periods of high-water table, in the late spring. The water-table map that was developed from this effort is very detailed, with one-foot-contour intervals in the center of the study area. A discussion of the results are presented in Appendix C, "Water Table Elevations in Eastern Barnstable, Massachusetts".

The observation-well inventory and subsequent water-level measurement and water-table mapping demonstrated that through the use of existing wells, detailed hydrogeological work can be performed. More observation wells could have been used in the preparation of the CCAMP water-table map by Heath (Appendix C) if more survey data were available. After the cost of well drilling, surveying was identified as the most expensive cost related to observation well installation.

4.3. <u>CCAMP Recommendations for Observation-Well Inventory</u>

CCAMP recommends the following:

1. Municipalities or Regional Planning Agencies (RPAs) should maintain observation well data bases that contain all of the information from Figure 4.1, the Well Description Form.

2. All new wells drilled should be surveyed to mean sea level and the owner should submit all the information from Figure 4.1 to the relevant agency.

3. The observation well data base should be maintained and its use in developing localized water-table maps should be promoted. All future entries to the data base and water-table map revisions should be well documented and maintained.

OBSERVATION WELL INVENTORY

WELL DESCRIPTION FORM

****

Well Identification______________________________

Status______________________ Lat./Long.__________

Accessibility____________________________________

Well Completion Date____________ Well Ownership________

Casing: Outer Diameter____________ Inner Diameter________
Material______________

Screen: Diameter______________ Length____________
* Width of Openings__________ * Material__________

Depths: Depth to top of casing from M.P.__________
* Depth to bottom of casing from M.P.__________
Depth to top of screen from M.P.__________
Depth to bottom of screen from M.P.__________
Depth, total of hole (ft below LSD)__________
* Depth, total of well (ft below LSD)__________
* Depth to water level (ft below LSD)__________
Top of casing segment below LSD__________
Bottom of casing segment below LSD__________
Depth to bottom of grout below LSD__________

Elevations: Elevation of top well casing above MSL__________
Elevation of land surface datum above MSL__________
Elevation of ground water ref. to MSL__________
Measuring point elevation__________
Measuring point height above LSD__________

Drilling Method______________ Drilling Fluid__________
Method of Development__________________________
Type of Surface Seal____________ Packing Material__________

Well Yield________________

Available Logs______________________________

Well use____________________________________

Method of Water-Level Measurement__________________

Source of Water-Level Data______________________

Sample Type and Frequency______________________

Remarks:

Figure 4.1 Observation Well Inventory Well Description Form

4.4 DRASTIC Analysis of Aquifer Vulnerability

The DRASTIC methodology is a model for assessing the vulnerability of contamination to an aquifer (described in Appendix D) and is based on an approach that addresses regional hydrogeological factors. Appendix D, "DRASTIC Mapping of Aquifer Vulnerability in Eastern Barnstable and Western Yarmouth, Cape Cod, Massachusetts," by Heath describes the methodology and the analysis that was performed in one of Barnstable's wellhead-protection areas, utilizing the water-table information generated by CCAMP. This effort assessed the variations in the vulnerability of groundwater to contamination in a 3650 acre zone of contribution in eastern Barnstable and western Yarmouth.

4.5 Identification of Zone II, the Wellhead-Protection Area

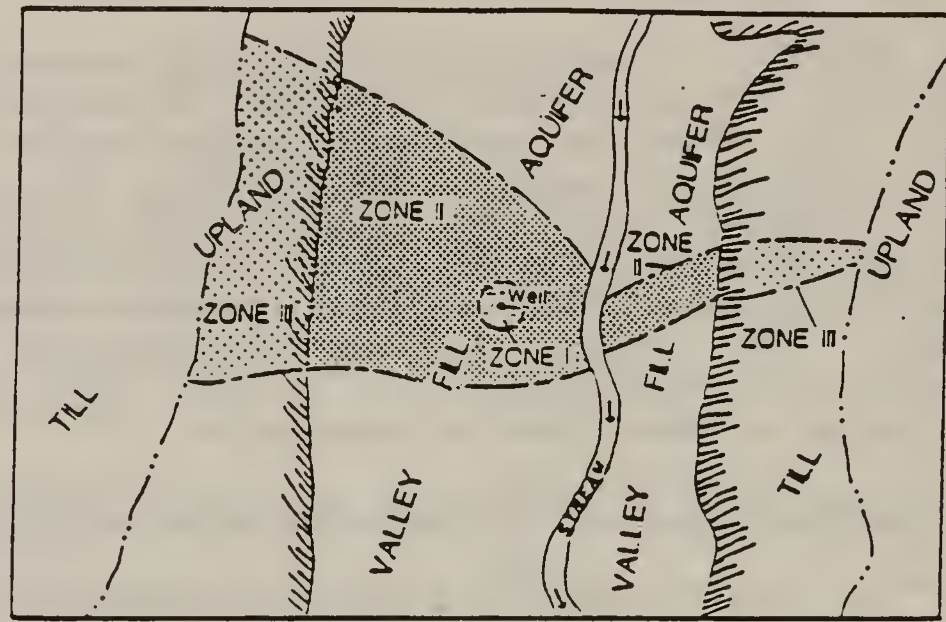
For the protection of public-water supplies, the Aquifer Assessment Group focused on the delineation and protection of the recharge areas for public-supply wells. These recharge areas, referred to as the zone of contribution (ZOC) or wellhead-protection area, are described in Massachusetts by Zones I, II and III (Figure 4.2). Zone I is the traditional 400 foot radius that a water supplier must own or control as required by DEQE Drinking Water Regulations (310 CMR 22.00) to protect groundwater from microbiological contamination. The primary recharge area to a well, Zone II is defined as the area that "recharges a well under the most severe recharge and pumping conditions that can be realistically anticipated. It is bounded by the groundwater divides which result from pumping the well and by the contact of the edge of the aquifer with less permeable materials such as till and bedrock." Zone III is "that land area beyond the area of Zone II from which surface water and groundwater drain into Zone II" (310 CMR 24.00). Zones I, II and III are two-dimensional map representations of a three-dimensional subsurface volume. The two- and three-dimentional areas of these zones in a typical New England Valley aquifer are depicted in Figures 4.2.

The delineation of a wellhead-protection area forms the basis for a comprehensive groundwater protection program. As Zone II represents that land area that provides the primary groundwater recharge to a public supply well, any contaminants that infiltrate the soil and are not immobilized or attenuated in the soil will move down into the aquifer and travel through the aquifer towards the well. For this reason, protection of the well's water quality must involve the proper management of all land uses in the wellhead-protection area. Figure 4.5 depicts typical land uses in a wellhead-protection area.

4.6 Approaches to Zone II Determinations in the Project Area

The Aquifer Assessment Committee was charged with the evaluation of existing methods to delineate wellhead-protection areas and the determination of alternative delineation approaches that would be appropriate for the pilot area. The Committee reviewed the methods used by SEA Consultants and CCPEDC to estimate wellhead-protection areas for the

a.



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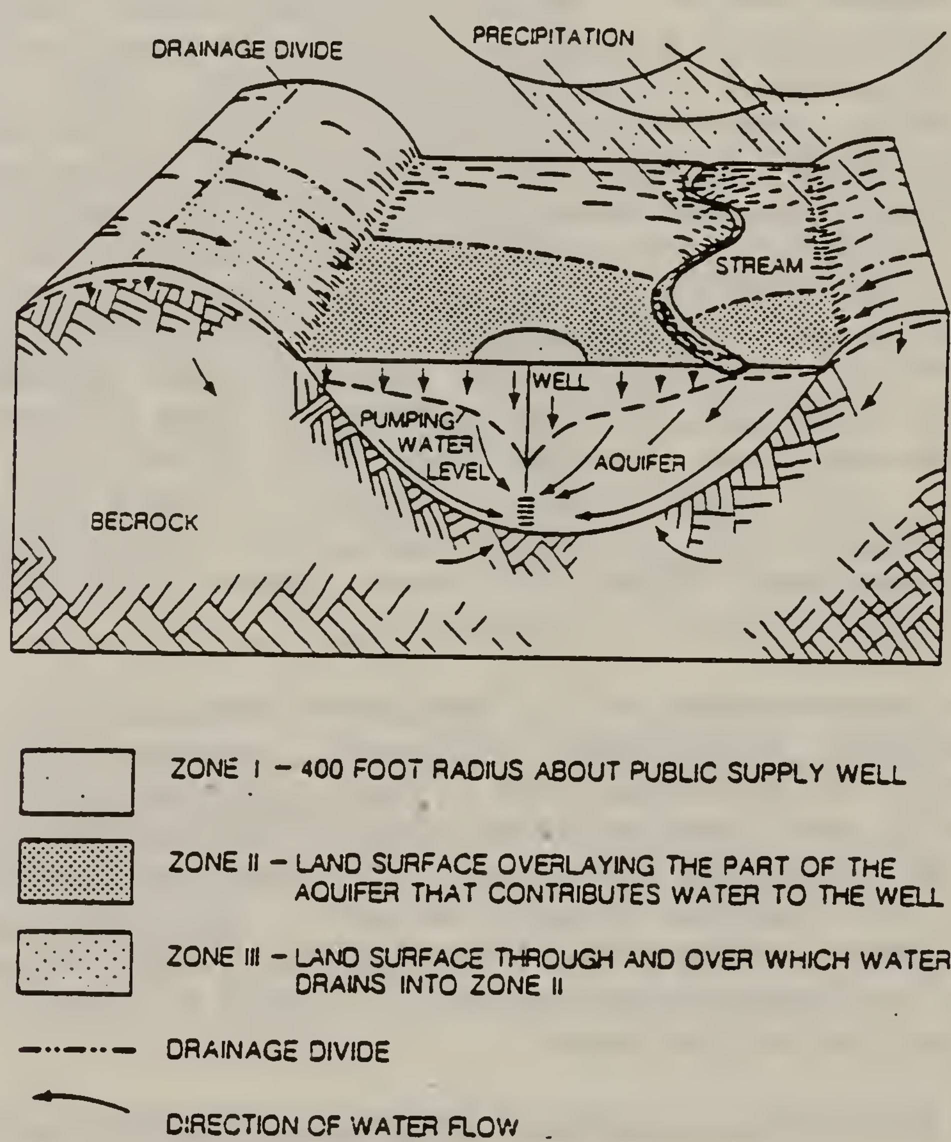

Figure 4.2 Two and Three-Dimension Views of a Glacial Valley Aquifer Showing the Zones and Stream which Contribute Water to a Public-Supply Well. a. Map view of Glacial Valley Aquifer. b. Hydrogeologic Cross-Section of Pumping Well. (Source: Frimpter, Donohue, and Rapacz, 1988)

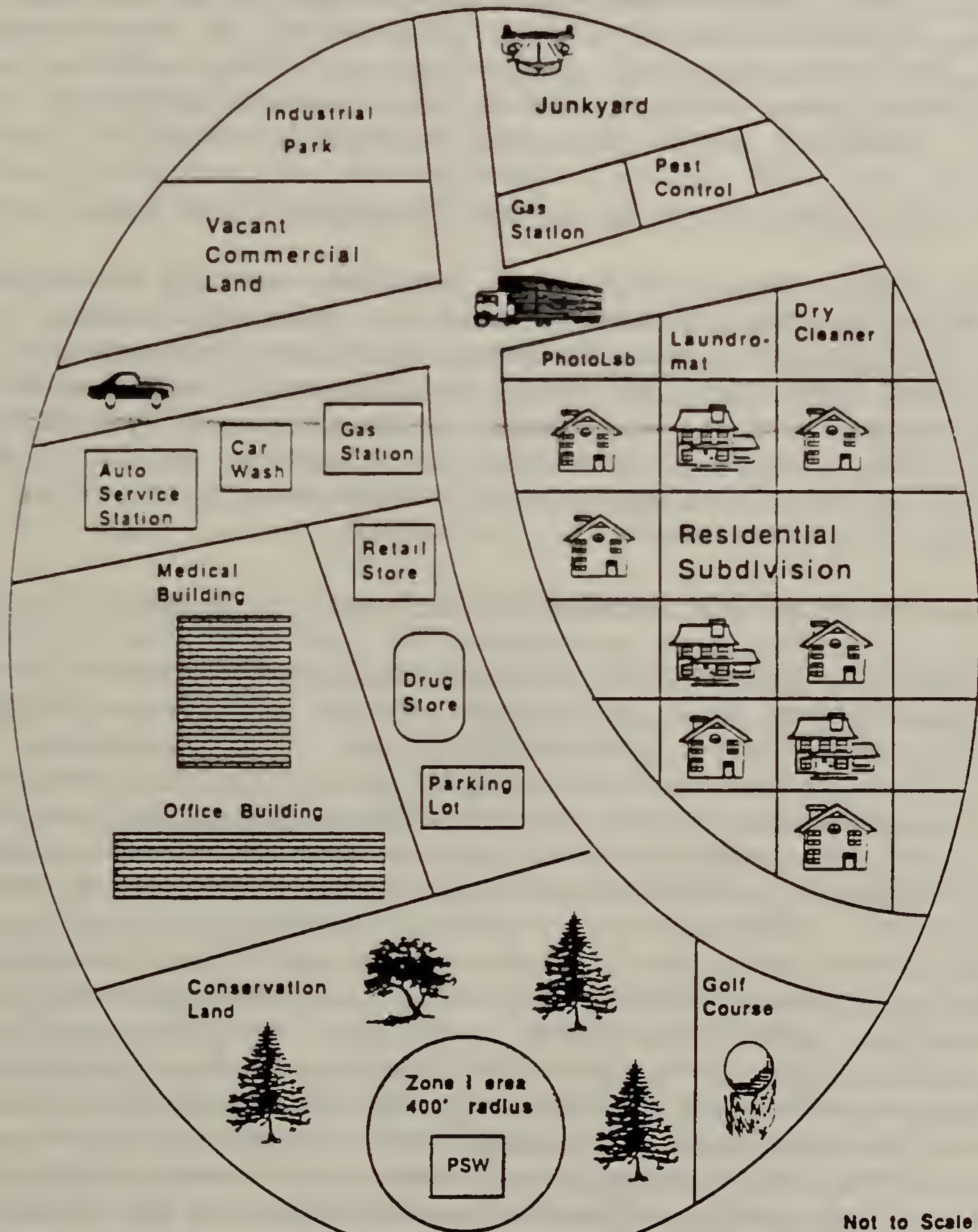

Figure 4.3 Typical Land Uses in a Zone II Area. (Source: "Guide to Contamination Sources in Wellhead Protection Areas by K. Noake, 1988)

public-supply wells in Barnstable and concluded that both approaches use analytical modelling techniques and yield reasonable delineations of the zones. Please refer to Appendix E, "Hydrogeologic Considerations of Zone of Contribution Methods Used by Cape Cod Planning and Economic Development Commission and SEA Consultants, Inc. for Public Supply Wells in Barnstable, Massachusetts," for a discussion of the methods of data reduction for use in such analytical modelling efforts. Appendix F, "CCAMP Aquifer Assessment Committee Report on Evaluation of Approaches to Determine Recharge Areas for Public Supply Wells," provides more information on the group's examination of wellhead-protection area determination methodologies as currently used on Cape Cod.

A key issue that faced the Committee was the determination of the optimum approach to wellhead-protection area delineation. Determining when the benefits of a more realistic model are outweighed by the expense of collecting the data necessary to adequately define such a model. In order to determine this cost/benefit point, the committee recommended that analytical and numerical modeling techniques be applied and compared in the project area, allowing a controlled demonstration of the shortcomings and benefits of each approach.

4.7 Initiation of the Comprehensive Numerical Modeling Project

An important outcome the Aquifer Assessment Committee recommendations was the initiation of a cooperative project between the DEQE/Division of Water Pollution Control, DEM/Division of Water Resources, the USGS and CCPEDC. The project consists of a demonstration of three-dimensional groundwater modeling to determine wellhead-protection areas. The demonstration included conditions where the advantages and disadvantages of the modeling approaches can be defined and compared with those of the analytical approaches. Opportunities for model verification with past and future water-level data will be utilized. The models will be applied to areas with complex boundary conditions, multiple aquifer systems, multiple withdrawal points, areally variable recharge, variable aquifer thickness, partial penetration, and changes in aquifer storage. Additional analyses may include comparison of the area of influence with area (zone) of contribution and determination of the upgradient boundary of the zone of contribution. Data acquisition requirements and costs will be also be described. This will allow the determination of the point at which the benefits of a more realistic model (more accurate wellhead-protection area delineation) are outweighed by the expense of collecting the necessary data to adequately define such a model. The results will be published by the USGS in May, 1990.

4.8 Documentation of Modeling

As an outgrowth of the Committee's examination of models for use in delineating wellhead-protection areas, the group was concerned that many models were not adequately documented; making it difficult to evaluate

their quality. Therefore, it is necessary that quality assurance measures provide for complete documentation for all hydrogeologic investigations.

Appendix G, "Quality Assurance of Ground Water Models Through Documentation", provides detail on the necessary aspects of model documentation. These documentation procedures should be followed for all groundwater flow and contaminant transport models. These procedures have been adopted as policy by the DEQE Division of Water Supply and are required in all reports which involve modeling work submitted to the Division.

4.9 Groundwater Protection for Communities on Private Wells

Protection of private wells and protection of areas that may be needed for future water supplies are the main groundwater management issues in Eastham. The work previously described focused on delineation and management of the wellhead-protection area to a public-supply well. For Eastham, relevant issues related to the groundwater resource that must be understood by local officials include: groundwater occurrence and flow patterns; rate of groundwater flow; contaminant fate and transport; the potential for salt water intrusion; and the recharge areas of private wells.

A detailed understanding of groundwater characteristics is essential in hazardous waste site investigations and in siting potentially contaminating land uses. In Eastham, one of the most common problems is the siting of septic systems near private wells. Without localized groundwater flow information, it is difficult to site wells and septic systems appropriately. Private-well contamination from septic systems, landfills, underground storage tanks, and commercial businesses using hazardous materials are the major threats to groundwater quality in this town.

The U. S. Geological Survey has completed significant hydrogeological work throughout the Cape. However, the USGS 1977 water-table map for the Eastham region was based on nine observation wells and is only representative of regional-flow conditions. The observation-well inventory conducted by the CCAMP Data Management Committee did not discover enough observation wells in Eastham that had been appropriately surveyed or were located such that a new water-table map could be generated. However, with the assistance of EPA, the Town of Eastham recently installed 14 water-elevation pond gauges to determine groundwater flow directions in the vicinity of the town landfill. Wells also will be drilled soon under a state grant to study Great Pond. It may then be possible to measure water levels and generate a detailed map.

4.9.1 Private-Well Recommendations

Based on this examination of the water-resource issues facing Eastham, the Aquifer Assessment Committee recommended that DEQE develop private-well guidelines and a model bylaw covering well construction, installation and abandonment. Private wells are particularly susceptible to contamination from sources such as a homeowner's disposal of household

and yard chemicals down the drain and into the septic system. The Aquifer Assessment Committee recommended that an educational brochure targeted to well owners be developed by CCPEDC and the Barnstable County Health and Environmental Department (BCHED) which has recently developed a model bylaw for private wells. (See Appendix J for Aquifer Assessment Committee recommendations on private wells.)

4.9.2 Protection of Future Public-Supply-Well Resources

The Aquifer Assessment Committee met with Eastham's Water Resources Advisory Committee and reviewed the existing state of knowledge of the town's groundwater resources to enable them to proceed with the development of a groundwater management strategy. In addition to helping Eastham understand its groundwater resources, the Aquifer Assessment Committee also demonstrated the use of a simple map overlay analysis to locate future public-supply-well sites. With the rapid rate of development on the Cape, it is important to identify such sites and adopt appropriate zoning regulations to protect them before the most suitable siting options are precluded by development.

The Committee conducted a map overlay analysis at a USGS quadrangle scale to evaluate this issue. The first map was of hydrological data, including water-table contours and brackish areas. Then, only considering hydrological characteristics, areas that would be "good, better, best" for water-supply development were selected. These areas were drawn to: limit the potential for salt water intrusion; avoid lowering pond levels; and have the shortest possible groundwater-flow paths (to limit the potential for contamination from upgradient sources). Areas of conflicting land uses, landfills, commercial businesses and appropriate buffers were then overlayed as another limitation for water-supply development. Parcels of town-owned land were then superimposed, and those that fell in the remaining "best" areas were considered to be the best sites for public supply well development. This process was repeated by computer, using the maps that were digitized for the CCAMP Geographic Information System (GIS) project. The resulting maps and a discussion of the procedure are contained in the separately published GIS report.

The map overlay methodology is a relatively straightforward procedure that can be performed by any town, either by hand or through the use of sophisticated GIS technology. It is important to begin the analysis by looking at the groundwater resource itself, and not beginning with the available parcels. The overlay analysis provides an initial determination of potential sites that may be suitable for siting water supplies. More specific on-site data may be evaluated in a subsequent overlay analysis to refine the number of suitable sites. At this point, considerable effort and resources will be necessary to evaluate the water-yielding characteristics of each site.

Once an accurate Zone II (zone of contribution) delineation is completed the delineated area can then be protected through the creation of special zoning districts or other means.

4.10 Protection of the Resource

Once the resource area has been defined and mapped, attention must focus on the management of potential sources of contamination. The Aquifer Assessment Committee developed technical guidance documents in two areas: (1) nitrate loading in wellhead-protection areas and (2) management and understanding of common land uses which may threaten groundwater quality. These two documents were designed to provide local officials with the technical basis for managing their groundwater-protection programs. These documents are clearly written on topics such as contaminant mobility.

4.10.1 Nitrate Loading in Municipal Wellhead-Protection Areas

Contamination by nitrate-nitrogen (nitrate) is one of the most widespread threats to groundwater quality on Cape Cod. Sources of nitrate include domestic on-site sewage disposal systems, municipal waste water treatment plants, industrial waste water, and fertilizer. Nitrate was chosen as the contaminant of concern by the Aquifer Assessment Committee for several reasons. Nitrate is assumed to act as a conservative chemical species in groundwater unaffected by sorption materials or by chemical reaction. The principal mechanism by which nitrate is attenuated is by dilution. It has been commonly demonstrated that the presence of nitrate in groundwater, also indicates the presence of other, more toxic, contaminants associated with waste water discharges. Adverse health effects associated with nitrate have prompted a federal drinking water standard of 10 milligrams per liter. However, on Cape Cod a maximum nitrate concentration of 5 milligrams per liter is widely used as the planning goal.

The Aquifer Assessment Committee reviewed and found inadequate the current approach of limiting development to one house per acre or greater as a protective measure. In an effort to address the potential for exceeding the recommended concentration of nitrate in municipal water-supply wells, a subcommittee developed an approach for evaluating the cumulative impacts of nitrogen-contributing land uses on water quality. This approach is the subject of a CCAMP Technical Report by Frimpter, Donohue, and Rapacz, "A Mass Balance Model for Predicting Groundwater Quality in Municipal Wellhead Protection Areas" which is available separately from NTIS.

The publication provides an approach for evaluating the cumulative impacts of nitrogen-contributing land uses to water quality in public-supply wells. The model, which employs a mass-balance accounting equation, calculates the resultant steady-state nitrate concentration at the wellhead. In simplified form, the equation is as follows:

$$\text{Nitrate Concentration in Well Water} = \frac{\text{Nitrate Load: Precipitation} + \text{Nitrate Load: Sources}}{\text{Total Volume of Water}}$$

With a Zone II delineation in hand, land uses within the Zone II must be identified and the potential nitrate load quantified for each. The total nitrate load within the Zone II is summed and entered into the mass balance equation along with other parameters such as nitrate concentration in areal recharge and the volume of water withdrawn from the well. Appendices to the nitrate-loading report provide a guide to the nitrogen loads associated with a variety of land uses and a program for summing these inputs on a personal computer.

The value that results from this calculation is the concentration of nitrate that can be expected in the pumping well after the system has reached equilibrium between the sources of nitrate and the sources of recharge. This equilibrium is reached when water particles from the furthest extent of the Zone II have reached the pumping well. This will require several years and is dependent on the geology, hydrology, recharge rate, and withdrawal of water.

This methodology was created to allow town planners and land-use managers to recognize the level of incremental development that will cause nitrate concentrations in municipal wells to exceed planning goals and/or health-based, water-quality standards. If used properly, this nitrate accounting model provides a technical basis for evaluating future development strategies and comparing trade-offs between various land uses and development proposals in wellhead-protection areas.

4.10.2. Guide to Contamination Sources for Wellhead Protection

The Aquifer Assessment Committee established the need to provide both local planning boards, conservation commissions, boards of health, and state officials with the guidance for scientifically-based, wellhead-protection strategies. This need was translated into the development of the CCAMP handbook "Guide to Contamination Sources for Wellhead Protection". The wellhead-protection strategies discussed include siting acceptable land uses in recharge areas of public-supply wells and determining those land uses that should be prohibited or strictly controlled by an aquifer protection district bylaw. This guide will be useful for investigating potential sources of groundwater contamination for each land-use activity.

The guide provides detailed, background information on 32 common land-use (business activity) categories and the associated 18 contaminant classes that are commonly used or generated as wastes. A poster-size matrix, "Land Use/Public-Supply Well Pollution Potential Matrix", developed for display is also included for use as a handy reference to quickly determine which one or more of the 16 contaminants or class of contaminants are commonly associated with each of the 32 land-use categories and which may render groundwater at a public-supply well undrinkable. In addition, this chart compares the pollution potential characteristics of those contaminants, indicating whether they have a low, medium, or high potential to contaminate groundwater if any are accidently released to the environment. The guide also contains information on best management practices that should be encouraged for each land use.

The following land uses and classes of contaminants are covered in the guide:

Land-Use Categories Covered

Agriculture/Golf Courses	Municipal Wastewater
Airports	Photography Labs/Printers
Asphalt Plants	Railroad Tracks, Yards/maintenance
Boat Yards/Builders	Research Labs/University/Hospitals
Car Washes	Road and Maintenance Depots
Cemeteries	Sand and Gravel Mining/Washing
Chemical Manufacturers	Septage Lagoons and Sludge
Clandestine Dumping	Septic Systems and Water Softeners
Furniture Stripping/Painting	Sewer Lines
Hazardous Materials	Storage/Transfer
Industrial Lagoons and Pits	Stables/Feedlots/Kennels/Piggeries/Manure Pits
Jewelry and Metal Plating	Stormwater Drains, Retention Basins
Junkyards	Stump Dumps
Landfills	Underground Storage Tanks (USTs)
Laundromats	Vehicular Services
Machine Shops/Metal Working	Wood Preserving

Contaminants Covered

Acids	Pesticides/Herbicides
Bases	Petroleum Products
Chloride	Phenols
Fluoride	Radioactivity
Metals (Except Fe/Mn)	Sodium
Iron and Manganese (Fe/Mn)	Solvents
Nitrates	Sulfate
Pathogens (Virus/Bacteria)	Surfactants (Detergents)

Figure 4.4, taken from the guide, is provided to illustrate the possible pathways contaminants may take depending on their characteristics and the hydrogeologic setting.

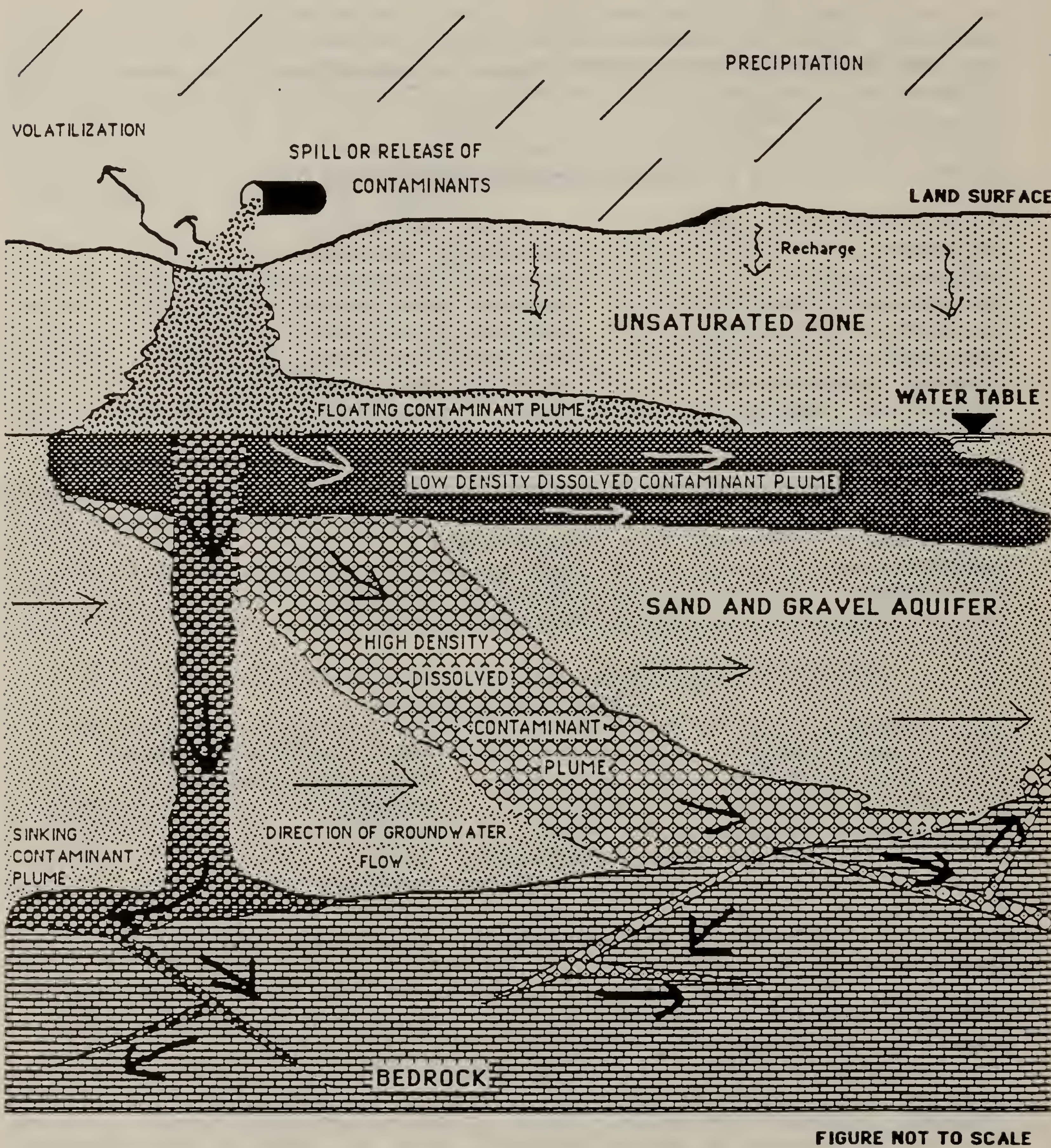

Figure 4.4 Diagrammatic Representation of those Factors Affecting Mobility and Attenuation of Contaminants. (Source: "Guide to Contamination Sources for Wellhead Protection" by K. Noake, 1988)

CHAPTER 5

GROUNDWATER DATA ISSUES

5.1 Groundwater-Data Initiatives

Groundwater protection involves a wide variety of specialized management programs (and their associated databases) within different offices and agencies at all levels of government. The Data Management Committee was charged with the critical task of exploring different issues and needs associated with groundwater-related databases. The group's primary charges were to: provide data gathering support for the other groups; make recommendations for improved data management; and explore the use of Geographic Information Systems (GIS) as a tool for groundwater management. However, the group focused most of its efforts on data collection for use by other CCAMP committees and on the lessons learned from the databases used. It was unable to spend extensive time in data gathering and simultaneously examine every groundwater related data system and to make in-depth recommendations.

The CCAMP Data Management Committee found fragmentation in groundwater related data systems. Through practical data-gathering efforts, came a number of recommendations for improved data structure, integration and accessibility. Many of the recommendations related to spatially referencing data and readying data for use in a GIS are contained in the CCAMP report, "CCAMP GIS Demonstration Project Report". Presented in this section are brief discussions of the group's groundwater-information inventory, data related recommendations and the GIS study.

5.2 Inventory of Groundwater Related Data Systems

To assist CCAMP in its work, the Data Management Committee extensively searched agency files and libraries to locate publications, files, maps and reports relating to groundwater, sources of contamination, land-use, planning and related topics. These items were computerized into a database so they could be used interactively by CCAMP members and are currently maintained by the EPA Region I library. An inventory of these data sources is available in the CCAMP report "CCAMP Bibliographies: Publications and Maps" and will be provided to officials working on Cape Cod groundwater management issues.

This inventory includes the following sources of information:

- Listing of published books, reports, articles, and maps which EPA, DEQE, CCPEDC, USGS have in their respective collections dealing with groundwater or sources of contamination.

- Entries relating to Cape Cod, particularly Barnstable and Eastham.

- Title, author, date of publication, publisher, abstract, and up to six key words or subject terms.

- All land-use, resource, or contaminant-source maps relating to Cape Cod, particularly Barnstable and Eastham.

- Map-scale and parameter information and a contact person.

5.3 CCAMP Data Recommendations and Observations

5.3.1 Interagency Data-Base Development

During the CCAMP project, the participating agencies expressed substantial interest in evaluating the potential for increased interagency use of existing databases and maps maintained by a single agency. The possibility of incorporating such information into a single, integrated database such as a statewide GIS or a data network with remote access was considered a potentially viable and attractive approach to better data management.

The Committee concluded that the possibility of establishing an interagency data base or data network involving CCAMP participating agencies is quite promising and deserves further detailed analysis. Uniform overlay maps, at common scale, of key environmental features such as wetlands and land use, as well as overlay maps and associated tabular data bases on regulated facilities and waste sources are of particular interest. However, much more work is needed on data standards and data verification procedures to ensure that the data are valid and decisions based on them are sound.

The development and maintenance of program-specific "data dictionaries" are necessary for an interagency data exchange. They identify information on source, dates of data collection, expected accuracy and other program-specific items.

There is also a need for all mapped data to be georeferenced. This methodology uses three standard and interrelated reference systems, latitude and longitude, state-plane, and universe transverse mercator. Without having map locations referenced to one of these standard systems, mapped information can not be accurately transferred from one map to another. Each agency must ensure that its own data is georeferenced properly to permit interagency sharing of mapped information. This is necessary within individual agencies before major interagency efforts proceed.

5.3.2 Interagency Groundwater Data Standards

It is important to continue to develop greater consistency among interagency databases to enhance cooperative information sharing efforts such as the utilization of geographic information systems. An interagency task

force of the CCAMP participating agencies and other interested agencies should be developed to identify key data elements and further define data standards. Specific data standards are needed immediately for databases relating to the following:

- municipal tax assessment maps
- observation wells
- regulated facilities
- water-quality data
- spill-report information
- land use

These standards should cover data accessibility, key elements, georeferencing, and quality control. Common data structures should be identified and utilized to facilitate data exchange.

Existing studies and committees focusing on data integration within DEQE, and cooperative efforts by the U. G. Geological Survey, Hazardous Waste Facility Site Safety Council and Executive Office of Environmental Affairs to establish a Massachusetts GIS have done valuable work for establishing data standards. Further work which considers and expands these efforts should be conducted by CCAMP participating agencies.

5.3.3 Need for Information Coordination Function in DEQE and CCPEDC

To encourage consistency across DEQE divisions, existing data coordination efforts within DEQE should focus intensively on technical issues associated with data base structure, development and integration. All Regional Planning Agencies (RPAs) should have a data coordinator to encourage consistency on data bases among towns and they should serve as the resource for data availability and data management issues.

5.3.4 Regional Consistency in Georeferenced Data

RPAs should make efforts to achieve regional consistency regarding georeferenced data. On Cape Cod, CCPEDC should assist towns on technical mapping issues and host a workshop on this topic with assistance from the CCAMP participating agencies. CCPEDC should encourage intertown cooperation and participate in establishing mapping standards.

A regional approach to creating and maintaining topographic, road and assessor's base maps to meet the needs of the region would aid in data integration efforts as needed for the development of a Geographic Information System Project. Various coordinate systems such as longitude and latitude, universal transverse mercator, and state-plane systems, all have appropriate applications and can be utilized in a GIS. The choice of a system for mapping particular features should be consistent regionwide. Guidance on accurately using and selecting these systems should be provided by the RPA with assistance from DEQE, EPA, and USGS, where needed.

5.3.5 Analysis of Groundwater Monitoring Information at DEQE

The appropriate DEQE divisions should build on recent information generated through inventory studies and quickly evaluate the automation of the data generated through programs that have groundwater monitoring components. This includes water quality, water level and monitoring, and observation-well characteristic data. Once automated, this data should be organized so that it may be usefully retrieved.

5.3.6 Water Supply and Quality Information Issues

To save time and accuracy, private-supply-well data from BCHED should be automated at the time of first entry in the laboratory. Currently, it is typed at the BCHED laboratory and then entered into a personal computer by CCPEDC.

All "request for analysis" forms, that accompany private-well samples for analysis by BCHED, should have map and parcel information recorded and/or be located on a specified map.

Public-supply water quality data is currently being computerized as part of a cooperative study funded by the DEQE Division of Water Supply (DEQE/DWS). Computerized access to this data base should be made available to EPA, regional planning agencies and other agencies with water management and data gathering responsibilites. The database should utilize appropriate geographic references for ease in locating all sampling points. Wells should have a common name, a unique DEQE permit number, and a number to permit cross-referencing databases.

USGS and DEQE/DWS should coordinate their efforts to locate public-supply wells. This would ensure that each agency would have identical well coordinates for each well location. In addition, all well databases should have a code for each well type (public-supply well, non community well, etc.).

5.3.7 Libraries

A central repository should be maintained for consultants reports and other studies completed at the local or regional level. Copies of these reports should then be maintained in the town's public library and the regional planning agency library and an index of these reports should be periodically provided by RPAs to EPA and DEQE libraries.

DEQE and CCPEDC should improve their technical library facilities. Procedures should be established for permanent filing and cataloging of consultant and engineering reports prepared for DEQE and municipalities at these libraries or other centralized locations. The EPA Region I library should play a consulting role (as they are currently doing for the Superfund Program) and share its approach to records management.

5.3.8 Water-Table Mapping and Observation-Well Issues

CCAMP participating agencies should set standards for observation-well data collection and surveying and encourage their adoption at all levels of government. Observation-well data should be maintained at CCPEDC for use in a Capewide observation-well network.

A computerized database involving observation-well data should be developed which includes such key elements as well number, location (coordinate system, town, USGS quadrangle, etc.), elevation and name of property owner. Use of GIS technology and existing databases such as GWSI (Ground Water Site Inventory) and STORET (Storage and Retrieval of Water Quality Information) should be evaluated for this purpose.

CCPEDC should attempt to coordinate the various consulting efforts to map and delineate Zone IIs so that water-table mapping or Zone II delineation does not stop at town boundaries.

5.3.9 Facility Index Data System (FINDS)

FINDS was designed to serve as an inventory of sites or facilities that are subject to federal environmental legislation or regulations. The system assigns a unique EPA identification numbers to each site and manages the volume of facility information associated with each numbered site.

EPA's FINDS facility information should be updated and reviewed on a scheduled basis. A program for field verification of FINDS sites needs to be established. Information reviews should include adding new facilities and updating regulated facility information such as addresses.

5.3.10 GIS Data Standards

Recommendations for a series of GIS data standards have been developed and are documented in the CCAMP GIS report.

5.4 Geographic Information Systems Technology: General

Groundwater managers at all levels of government must utilize diverse and varied types of data, including scientific information on complex, groundwater resource interrelationships and land-use inventory information on a wide variety of potential sources of contamination. Traditional databases are fragmented, timeconsuming to access, and requires extensive work to use data from different sources. Unlike these systems, Geographic Information System (GIS) technology provides a powerful tool for groundwater management. As represented in Figure 5.1, this computerized system for storing, analyzing and displaying spatially-related information is revolutionizing the approach to environmental management nationwide.

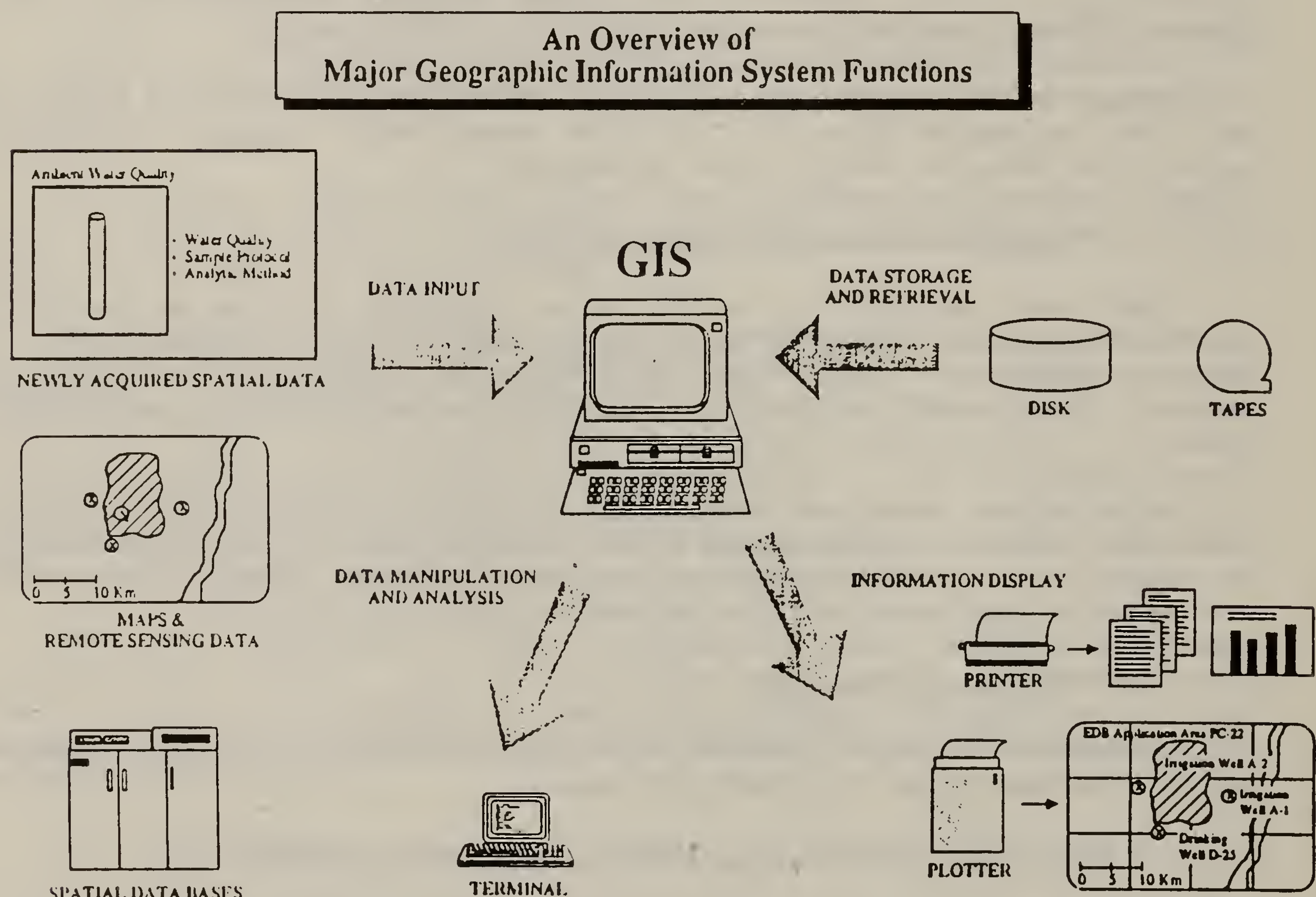

Figure 5.1 An Overview of Major Geographic Information Systems Functions.

GIS integrates computer graphics and an automated database manager into a single interrelated software system that can serve a variety of functions. It also has the capability for analysis techniques, including overlaying data layers of different scales and has remarkable graphic-display capabilities.

The CCAMP GIS effort utilized the ARC/INFO GIS software developed by Environmental Systems Research Institute (Redlands, CA). ARC has the capability to maintain the spatial location of map features such as lines, points, and polygons while INFO stores and processes a virtually unlimited amount of attribute information which describes these features.

5.4.1 The CCAMP GIS Project

The CCAMP GIS project was a short-term, nine-month effort jointly funded by DEQE and USGS and was developed under the auspices of CCAMP. The primary objective was to demonstrate the usefulness of GIS technology in assessing the risk of contamination to public-supply wells from a number of contamination sources. An integral component of the demonstration was an evaluation of the data requirements necessary to utilize GIS. Although the demonstration was short term, it was designed to provide insight to others considering a long-term investment in GIS. The rationale for beginning this project was based on the existing CCAMP committee structure, the data gathering that had already begun, local contacts, and the knowledge of groundwater-management issues provided .

The CCAMP GIS project concentrated on groundwater protection at three different levels of analysis: (1) the zone of contribution to nine public-supply wells in Barnstable, a highly urbanized area; (2) in the rural, seasonally populated town of Eastham; and (3) the Cape Cod peninsula. Each of these provided an example of the types of applications for which GIS may be used. Management senarios were developed to analyze some of the major groundwater issues facing decision makers. The scenarios selected for in-depth analysis included:

1. Selection of potential sites for future public water-supply development and for a stump dump in Eastham.

2. Examination of risk to public-supply wells from landfills Capewide in order to set enforcement priorities.

3. Examination of the compatibility of zoning ordinances and land use within a zone of contribution which includes portions of two towns.

4. Comparison of contamination risk to public-supply wells from existing land uses and the land-use pattern when full development (build out) has occurred according to zoning within a zone of contribution.

5. Assessment of contamination risk to public-supply wells from underground storage tanks within a zone of contribution.

6. Comparison of delineated zones of contribution with a proposed interim half-mile radius for use by DEQE for those areas where such zones have not been delineated.

7. Application of CCAMP nitrate loading model in a wellhead-protection area.

The demonstration project indicated that geographic information systems can be successfully used for diverse planning and regulatory purposes related to groundwater protection. It is hoped that the lessons learned from this project on georeferencing data, data integration, issues involved in setting up such an extensive effort, and GIS applicability will be helpful to GIS efforts elsewhere. The project report should also be helpful in encouraging the upgrading and integration of databases for their eventual use in a GIS or an interagency data base. The existing GIS overlays that have been digitized for this CCAMP study effort should also be utilized in future, localized GIS efforts that will follow CCAMP. A full discussion of the CCAMP GIS project and accompanying maps are contained in a separate CCAMP report, "A Demonstration of Geographic Information System for Ground Water Protection" and a separate report by the U. S. Geological Survey.

CHAPTER 6

ANALYSIS OF LAND-USE FOR TOXIC AND HAZARDOUS MATERIALS WITHIN A ZONE OF CONTRIBUTION *

6.1 Study Plan

CCAMP undertook an intensive land-use study within one wellhead-protection area in the town of Barnstable. The goal of this study was to provide a more thorough understanding of the information necessary for an effectively designed and implemented resource-based groundwater management plan. An examination was conducted and evaluated the following parameters: (1) the adequacy of hydrogeological and contaminant-source data, (2) the appropriate tools for management of specific contaminant generating activities, and (3) the institutional arrangements within and among levels of government required for effective program implementation. By locating and characterizing existing land uses and potential risks of contamination from those land uses, CCAMP evaluated the effectiveness of existing land-use-management programs.

In conference with the Town of Barnstable's Office of Planning and Development, a wellhead-protection area identified by the Town as Zone of Contribution #1 (ZOC #1), was chosen for CCAMP's land-use study because of the complex challenges it posed. This ZOC presents a prototype for studying groundwater management for many potential types of contamination sources, large and small, found on the Cape and elsewhere.

6.2 Characteristics of Barnstable Zoc #1

ZOC #1 surrounds nine public-supply wells and six future well sites. It provides 31 percent of the water to the town (11.7 million gallons/day) and encompasses 3650 acres within two jurisdictions, Barnstable and Yarmouth. This area comprises the most highly developed commercial area on Cape Cod, yet there is still substantial vacant land targeted for further development.

The commercial area within ZOC #1 is extensive and varied. Specific activities include the municipal airport (second busiest in Massachusetts), the municipal waste water treatment plant, an industrial park (largest on Cape Cod), and 140 retail enterprises including the Cape's largest shopping mall. A junkyard, numerous medical offices, 119 automotive, commercial and service related businesses, and a large number of residential parcels, 300 of which are unsewered are also located in this area.

* This chapter is largely taken from: Gallagher, T. and L. Steppacher. Management of Toxic and Hazardous Materials in a Zone of Contribution on Cape Cod. In: Proceedings for the Conference on Eastern Regional Groundwater Issues, Burlington, VT, 1987.

6.3 Inventory Approach

6.3.1 Data Gathering and Automation

A detailed inventory of the land-use data within ZOC #1 was gathered from the data available through existing regulatory programs at all levels of government (Table 6.1). The evaluation of this data enabled CCAMP to examine its quality and to determine the effectiveness of these regulatory programs. This inventory also identified data gaps and thus served as the basis for gathering additional information for characterizing land use within the ZOC.

Table 6.1 provides a brief summary of the local, state, and federal regulatory programs examined in this study, including information that is not detailed elsewhere in the text. Listed are the regulated facilities covered by these programs, the types of data available, the data quality and the level of implementation (i.e. how many of the facilities that

Figure 6.1 Location of Zone of Contribution #1

Table 6.1 Major Data Sources Utilized

Town Bylaw, State/Federal Regulation	Implementing Agency	Regulated Sites or Activities	Available Information	Data Quality and and Availability	Level of Implementation	Time Requirement for Gathering/ Screening Data
Barnstable Bylaw (Article XXXIX) Control of Toxic and Hazardous Materials	Board of Health	Sites at which toxic or hazardous materials are stored in quantities totalling more than 50 gallons (liquid) or 25 pounds (dry). Exceptions: fuel oil in conformance with state regulations, and materials stored at private residence.	- Quantities of waste types stored. - Storage Method - Materials hauled - Inspection Reports	- Fair - Paper files - Data inconsistently reported	- Variable, based on inspection priorities - Generally good	5 days
Yarmouth Bylaw (Chapter 9) Handling and Storage of Hazardous Materials	Board of Health	Same as above	- Quantities of waste type stored. - Materials hauled. - Spill plan filed. - Location in relation to ZOC	- Automated - Good	- Variable	1/4 day

Table 6.1 Major Data Sources Utilized

Town Bylaw, State/Federal Regulation	Implementing Agency	Regulated Sites or Activities	Available Information	Data Quality and and Availability	Level of Implementation	Time Requirement for Gathering/ Screening Data
Department of Public Safety UST Regulation 527 CMR 9	Department of Public Safety (DPS) Local Fire Department	All LUSTS Exceptions: - Residential & farm tanks <1100 gallons - All heating oil tanks for consumptive use on premises must provide notification to local fire department and DPS.	- Capacity - Construction material used - Contents - Age - Status - Location	STATE: - Automated - Time backlog - Tank characterization not available by location LOCAL: - Paper files - Disorganized	STATE: - Fair LOCAL: - Good	9 days
Oil Burner Permits 527 CMR 4	Local Fire Department	- Storage of oil above and below ground with oil-burning equipment adjacent to buildings	- Construction material used - Age - Size - Location address above or below ground	- Paper files - Variable by fire department	- Variable	1 day
Incident Response - Spills and Leaks MGL C. 21E	MA DEQE Division of Hazardous Waste (DHW), Office of Incident Response	Any owner/operator must report a release of oil or hazardous material. No minimum quantity specified. No current regulations.	- Spill and leak initial inspection form. - Location - Cause	- Not automated - Filed by DEQE Region (not town) - Follow up is difficult to obtain	- Good	1 day

Table 6.1 Major Data Sources Utilized

Town Bylaw, State/Federal Regulation	Implementing Agency	Regulated Sites or Activities	Available Information	Data Quality and and Availability	Level of Implementation	Time Requirement for Gathering/ Screening Data
RCRA Subtitle C Hazardous Waste Manifest Program 310 CMR 30	EPA - Notification DEQE - Manifest	SMALL QUANTITY GENERATORS - Facilities producing >20 kilograms/ month of hazardous waste or >1 kilogram/month of "acutely hazardous" wastes, or storing wastes totalling these amounts when the wastes are removed for disposal. LARGE QUANTITY GENERATORS - Same as above except quantity is >1000 kilograms/month.	- Quantities of waste hauled annually - Information by waste category - Annual facility reports (for large quantity generators only)	- Good - Automated - Time backlog of approximately 5 months	- Improving	- No verification
(For nitrogen loading)	MA Department of Employment Security		Number of employees for small businesses	Fair		- 4 weeks Total (nitrogen loading)
Barnstable/ Yarmouth Parcel Maps (For nitrogen loading)	Town Tax/Assessor's Office	Taxable Property	- Delineation of parcels - Square footage of store and office space.	Good	Good	- 4 weeks Total (nitrogen loading)
Barnstable Health Regulation (For nitrogen loading)	Barnstable Board of Health	Restaurants, motels, and hotels	- Number of seats/ restaurant - Number of rooms/ motel or hotel	Good	Good	- 4 weeks Total (nitrogen loading)

Table 6.1 Major Data Sources Utilized

Town Bylaw, State/Federal Regulation	Implementing Agency	Regulated Sites or Activities	Available Information	Data Quality and and Availability	Level of Implementation	Time Requirement for Gathering/ Screening Data
MGL C. 21E Initiative 14	DEQE-DHW	Listing of all confirmed hazardous waste sites in state.	- Site listing - Address - Type of release - Status			- no verification
Right to Know Program MGL C.111F 310 CMR 5	DEQE - Right to Know Program	Any facilities using or storing substances on MA Substances List must submit Materials Safety Data Sheets (MSDS) to DEQE.	- Materials Safety Data Sheets - All information is confidential - No quantity information	- Automation proceeding slowly. - High potential limited by lack of quantity information and confidentiality	- Poor (many businesses have MSDS but have not submitted to DEQE)	- 1 day
Groundwater Discharge Permit Program 314 CMR 5	DEQE - Division of Water Pollution Control	All industries discharging to the ground in any amount must be permitted and must meet effluent standards. Domestic flow >15,000 gallons/day also covered	- Flow volume - Effluent characteristics - Groundwater monitoring results	- Good - Plans to automate monitoring-well data	- Poor for commercial facilities	- 1/2 day

should be covered by a particular program are actually regulated?). The column labeled "time requirements" represents the actual time required to gather and roughly verify the data. Verification efforts focused on the facility locations so this information could be utilized by the Geographic Information Systems (GIS) methodology. A discussion of these data for ZOC #1 is presented elsewhere in two CCAMP GIS reports: "A Demonstration of Geographic Information System for Groundwater Protection" (1988) and "Assessing Risk to Water Quality at Public Water Supply Sites, Cape Cod, Massachusetts", _In_ _Preparation_ by the U.S. Geological Survey.

Several other data sources that should be examined in any wellhead protection (WHP) inventory but which were not important in ZOC #1 include: EPA's RCRA Interim Status Files (information on hazardous waste, transfer, storage and disposal facilities), the NPDES permit program, the Underground Injection Control (UIC) program, and the Superfund program.

In order to organize and analyze information from these disparate program files, a hierarchical set of dBase III files was utilized. A master file was developed containing map, parcel, land-use numbers, business name and address, sewer information and a column listing for each of the regulatory programs that were examined for regulating specific land-use activities on a particular parcel. Separate data bases contained specific program information keyed again by map and parcel numbers and business name.

6.3.2 _Data Quality_

In general, the data in almost all of the programs as listed in Table 6.1 examined was of poor quality, time consuming to retrieve, not current, and rarely spatially referenced. The reason for this deficiency seems to be that these program files are seldom used by decision-makers in other programs. A great deal of very useful information was uncovered (particularly at the local level) that should be utilized on a routine basis for decision making. Without a perceived use for the data, there is little incentive to maintain readily usable files. Unfortunately, data retrieval was frequently hampered by such problems as indecipherable hand writing, forms without key information, and difficulty in retrieving automated data.

There is a critical need for coordinating data gathering requirements at all levels of government with the goal of obtaining complete information as a first step in the protection of any critical area. Where possible, for ease of access, key data should be standardized, spatially displayed and automated. There should also be an increase in information exchange across programs, and among federal, state and local levels of government. Siting water supplies and other land uses, targeting enforcement, and checking program compliance will all be facilitated by easy access to shared information.

6.4 _Findings_

CCAMP's inventory of potential contamination sources provided an extensive characterization of the use of hazardous materials and the risk

posed to the public-water supply within this ZOC. The results of this inventory, as summarized in Table 6.2, clearly indicates the presence of toxic and hazardous materials and the need for a strong management strategy to protect the groundwater resource.

Table 6.2. Inventory of Potential Contamination Sources of Toxic and Hazardous Materials Reported within ZOC#1 (1) During April 1987.

Barnstable, Yarmouth, and DEQE Records (dates within brackets) for Various Categories	
USTS (1/87) (38 percent >20 years old)	186 tanks
SPILLS/LEAKS (1985-1986 inclusive)	21 releases
CONFINED HAZARDOUS WASTE SITES (4/15/87 - all petroleum releases)	6 sites
TOXIC AND HAZARDOUS MATERIALS STORERS (5/87)	141 storers
TOTAL WASTES MANIFESTED FROM ZOC #1 IN 1986 (12/86)	22,635 gallons 43,955 pounds
NOTIFIERS: HAZARDOUS WASTE MANIFEST PROGRAM	45
RIGHT-TO-KNOW MSDS FILED AT DEQE	23 MSDS
TIGHT TANKS (INDUSTRIAL)	1 tanks
GROUNDWATER DISCHARGE PERMITS (INDUSTRIAL)	1

(1) Dates in parentheses indicate the most recent data utilized for this study.

6.4.1 Underground Storage Tanks (USTS)

The major conclusions of the UST investigation within this ZOC were twofold: (1) 38 percent of the 186 tanks located were twenty years or older; (2) 65 percent of all tanks were constructed of steel. These metal tanks pose a hazard because they are more susceptible to corrosion and subsequent leakage than fiberglass tanks which are favored today. Spatial distribution of the tanks is depicted in Figure 6.2. Refer to Table 6.3 for a summary of the tank data.

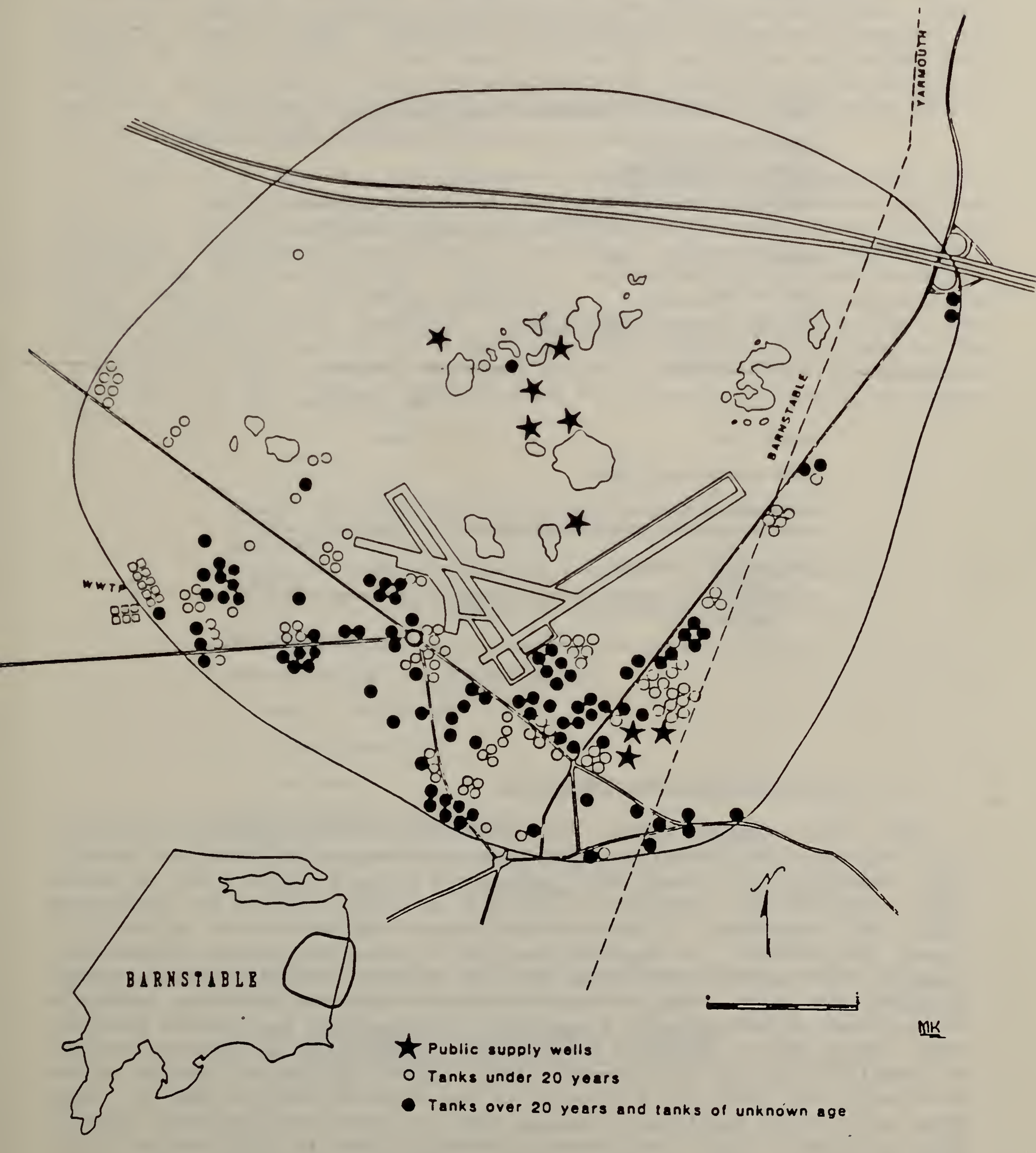

Figure 6.2 Underground Storage Tank Locations in ZOC #1.

Table 6.3 Inventory of Underground Storage Tanks within ZOC #1

Town of Barnstable and Yarmouth Fire Department Records for Various UST Categories of Interest	Number Reported
RESIDENTIAL FUEL OIL TANKS	13
TANKS IN USE	116
TANKS OUT OF USE OR STATUS UNKNOWN	70
TOTAL ON 82 SITES	186 tanks
TOTAL V LUME	856,225 gallons
AVERAGE SIZE	4,603
BURIED LONGER THAN 20 YEARS	71
CONSTRUCTED OF STEEL	122
STEEL TANKS BURIED LONGER THAN 20 YEARS	50
CONSTRUCTED OF FIBERGLASS	32

(1) Construction material of all other tanks over 20 years of age is unknown.

6.4.2 Toxic and Hazardous Materials

The local toxics bylaws for Barnstable (Article XXXIX "Control of Toxic and Hazardous Materials") and Yarmouth (Chapter 90 "Hazardous Materials, Handling and Storage of") implemented by each town's Board of Health (BOH), require all facilities storing substances which are considered toxic and hazardous, in amounts totalling 50 gallons liquid volume or 25 pounds dry weight, to register the type of materials stored, quantities, location and method of storage with the Board of Health. These programs provided the most complete set of data on toxic and hazardous materials for purposes of this study. Barnstable's BOH provided much useful information within ZOC #1, however, complementary information in Yarmouth was not as complete because enforcement efforts against businesses located in the Barnstable ZOC were not a priority of the Yarmouth Board of Health. This data gap is not significant because there are very few commercial activities or other toxic and hazardous material users in this portion of ZOC #1.

One hundred and forty one businesses were registered with the Barnstable and Yarmouth Boards of Health under the local toxics bylaws. Data derived from the DEQE - Hazardous Waste Manifest Program were assessed in light of this listing, and each of the 43 facilities covered by that program were found to also be covered by the local bylaw. In addition, only 23 companies filed Materials Storage Data Sheets (MSDS) with DEQE's Right-to-Know Program (Table 6.2).

Tables 6.2 and 6.4, and Figure 6.3 characterize the extent and location of toxic and hazardous materials in ZOC #1. Quantity data reported as part of Barnstable's bylaw are quite variable and do not present an accurate depiction of activities in the ZOC #1. Generally, a nearly equal proportion of reporters were storing oil, synthetic organics and miscellaneous substances (including antifreeze). However, approximately two thirds of the total quantity stored, approximately 20,000 gallons, was oil, generated by auto-related facilities which comprise 40 percent of the reporters. The records at the local boards of health did not distinguish the type of oil stored (home-heating oil, diesel, waste oil, or engine oil).

Table 6.4 Information Reported to the Barnstable and Yarmouth Boards of Health as Required by the Toxic and Hazardous Materials Bylaws During April 1987.

Category	Number
Total Number Reporting	141
Number Storing Toxic and Hazardous Materials	
Heavy Oil (not defined)	73
Synthetic Organics	65
Miscellaneous	69
Number of Hazardous Waste Haulers	51
Volume of Toxic and Hazardous Materials Stored	
Average quantity of waste oil stored (1)	243 gallons
Approximate total quantity stored (2)	34,000 gallons

(1) Represents 43 of the 141 facilities reporting

(2) Quantity information was not provided by all reporters

Local Board of Health (BOH) inspections confirm that service and repair garages handle more waste than other commercial businesses in the Zone. Although Table 6.5 indicates that only 44 percent of the total have

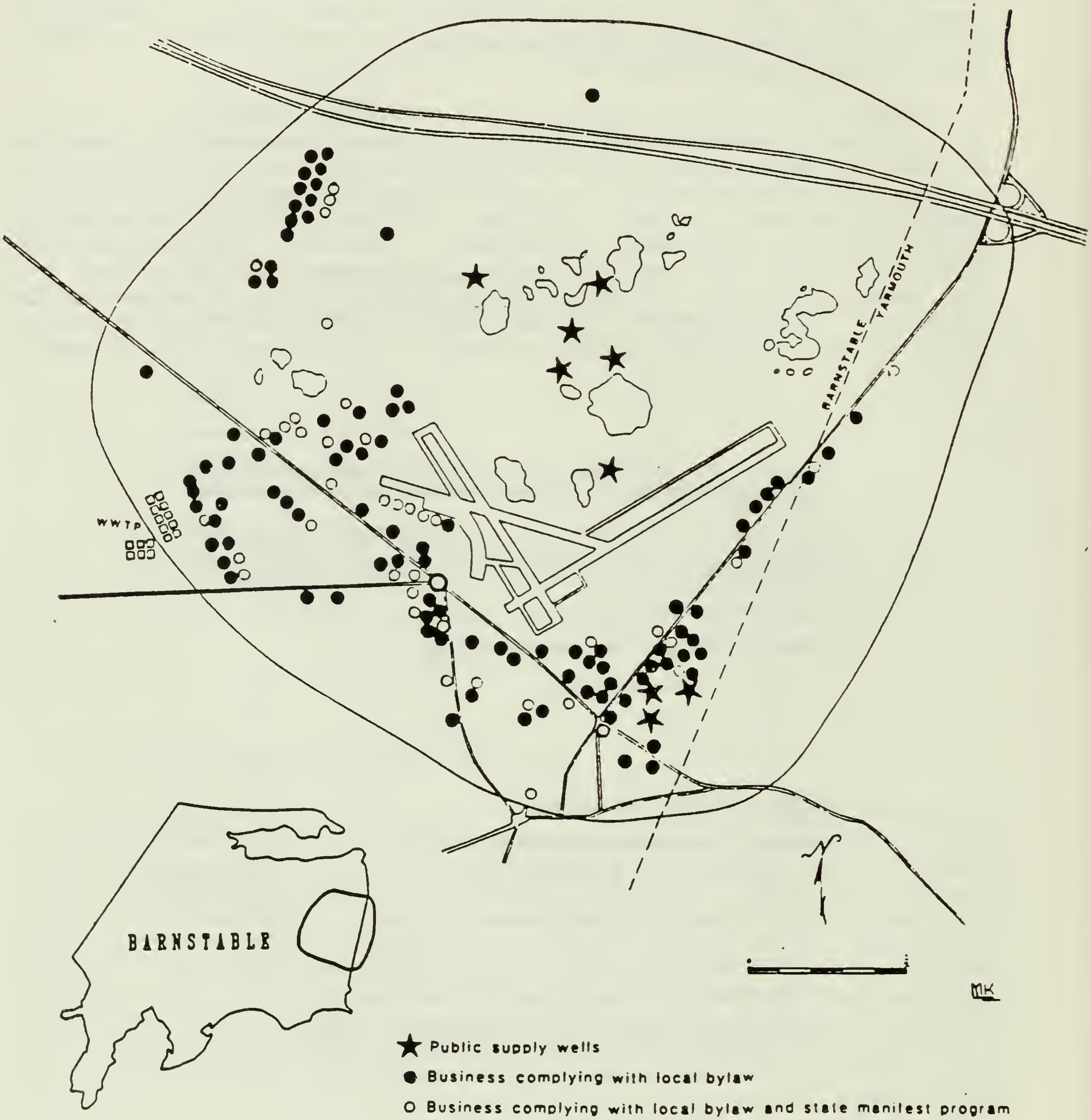

Figure 6.3 Extent and Location of Toxic and Hazardous Materials In ZOC #1.

Table 6.5. Characterization of Toxic and Hazardous Materials in ZOC#1 by Land-Use Type as Reported by Local Businesses to the Barnstable and Yarmouth Boards of Health.

Land-Use Type	No. Reporting	Total Present	Percent Reporting (1)
Automotive Related	55	119	44
Auto Repair (only)	25	33	76
Storage, Warehouse, and Distribution Facilities	24	121	20
Manufacturing	12	21	57
Retail	27	140	19
Medical Office Buildings	1	17	6
Other: Bus Depots, public buildings, office buildings	21	37 +	?

(1) These percentages may be misleading. A site visit is necessary to confirm these land uses actually generate toxic and hazardous materials. This Table should be used primarily as a guide.

registered with the BOH; many of those not registering were gas stations without service facilities (included in the underground storage tank inventory), tire shops and car rentals. When these are omitted, there was at least a 70 percent compliance rate with the bylaws.

6.4.3 Hazardous Waste Manifested

A summary of the manifested wastes hauled from ZOC #1 by licensed haulers with totals for both 1985 and 1986 is provided in Table 6.6. While the total amounts of waste hauled increased somewhat from 1985 to 1986, the most significant increase was in the number of businesses with EPA notification numbers and in the number manifesting waste. This shows an increase in program implementation and a significant amount of waste being hauled from a critical groundwater protection area. Figure 6.3 shows the proximity of toxic and hazardous-materials storers, registered in accordance with the Barnstable Board of Health's Toxic and Hazardous Materials Bylaw, to public-supply wells.

6.4.4 Spills and Leaks

Data on spills and leaks from DEQE's Office of Incident Response for the two year period 1985 through 1986 provide an indication of the probability and extent of spills generally in the Zone. The results, as presented in Table 6.7, indicate that approximately one incident per month occurred within the Zone. Of this number, 43 percent were due to leaking underground storage tanks. Additionally, the State inventory of confirmed

Table 6.6 Inventory of Hazardous Wastes Manifested within ZOC#1 During 1985-1986 as Recorded by DEQE's Division of Hazardous Waste (1).

1. NUMBER OF FACILITIES MANIFESTING WASTES (2, 3)

Facility Type	Number Reporting 1985	Number Reporting 1986
Facilities with EPA Notification Numbers (All Large- and Small-Quantity Generators)	33	45
Number of Large Quantity Generators	2	2
Number of Facilities Manifesting Wastes	18	27
Number of Small Quantity Generators Generating <100 Kilograms/Month (Based on Yearly Totals)(1)	11	15

2. QUANTITY MANIFESTED ACCORDING TO DEQE MANIFEST WASTE CODE (2, 3).

DEQE Manifest Waste Code	Quantity Reported 1985	Quantity Reported 1986
M001 (Waste Oil)(2)	17,972 gallons 5,215 pounds 130 cubic yards	8,475 gallons 11,790 pounds
M002 (PCB Wastes)	1,659 gallons 15,100 pounds	7,195 gallons 2,270 pounds
D001 (Ignitable)	1,575 gallons 6,000 pounds	515 gallons 3,730 pounds
D002 (Corrosive)	500 gallons	3,740 gallons
F001 (Spent Halogenated Solvents Used in Degreasing)	220 gallons	440 gallons
F002 (Spent Halogenated Solvents- Primarily from Dry Cleaning	6,730 pounds	5,055 pounds
F003 (Spent Nonhalogenated Solvents; Xylene, Acetone	0	1,785 gallons
F004 (Spent Nonhalogenated Solvents; Cresols, Cresylic Acid, Nitrobenzene)	0	80 pounds
F005 (Spent Nonhalogenated Solvents; Toluene, Methyl-Ethyl Ketone, Carbon Disulfide)	0	415 gallons
M099 (Nonhazardous Waste; antifreeze) (3)	0 0	110 gallons 600 pounds
TOTALS	21,917 gallons 33,045 pounds 130 cubic yards	22,635 gallons 43,955 pounds

(1) Collected from the DEQE Division Hazardous Waste Manifest Compliance Section of the Licensing and Enforcement Program.
(2) Regulatory authorities for the collection of this data: 40 CFR Part 262.20 of the federal regulatory code which supports EPA's RCRA program for hazardous-waste management and 310 CMR 30.31 of the state regulatory code.
(3) Refer to page 60 for a discusssion of manifesting.

hazardous waste sites identified six locations in ZOC #1, all of which were the result of petroleum-product contamination.

Table 6.7 Number of Spills and Leaks Reported to DEQE in ZOC #1 from January 1985 to December 1986.

Category	Number of Occurences
SOURCE OF SPILL OR LEAK	
Underground Storage Tanks	9
UST Pipe Failure	5
Above Ground Tanks	1
Transformers	5
Drums	2
Miscellaneous (from pipes hoses,etc.)	4
TOTAL	21

Source: DEQE Southeastern Regional Office, Division of Hazardous Waste, Office of Incident Response, Lakeville, MA.

6.4.5 Road Salt

In 1986, the Massachusetts Department of Public Works, recognizing the sensitivity of the aquifer on Cape Cod, reduced its application rate of sand and salt from a 1:1 ratio to a 4:1 ratio on most roads. Only those highly travelled state roads received the traditional application rate. Within ZOC #1,only Route 6 in the northern portion of the ZOC is receiving this higher salt application rate.

6.4.6 Application of the Nitrate Loading Formula

Approximately 70 percent of the Zone is unsewered. The major portion of the collection system for the waste-water treatment plant is in the southern portion of the Zone and services some of the larger commercial activities. However, there is still an assumed threat to the wells from nitrogen. Utilizing the predictive nitrate-nitrogen loading formula derived by CCAMP participants, an estimated load was calculated within ZOC #1, (see CCAMP nitrate nitrogen loading report by Frimpter, et al., 1988) conclusions point heavily to the impact of the Barnstable Waste-Water Treatment Plant as a contributor to the total nitrogen load. Consequently, management alternatives must recognize that while review of new activities within ZOC #1 is important, primary attention must focus on the operations of the waste-water treatment plant.

6.5 Discussion

6.5.1 Risk to Public-Supply Wells

The potential risk facing public-water supplies may be characterized in various ways as a result of the inventory undertaken within ZOC #1. The most overwhelming conclusion is the high potential threat posed by petroleum products.

Underground storage tanks are the most pervasive potential contaminant source in this ZOC. Not only are there 186 within the entire zone, a large majority of these are clustered in the southern portion around the Hyannis business district close to three of the public-supply wells. A 1320 foot (1/4 mile) radius from the three public-supply wells in the southeastern portion of the zone illustrates the degree of risk presented by these tanks. Within this distance there are 45 tanks. Fourteen of these are over 20 years old and 11 are of an unknown age but in the absence of this information the Department of Public Safety regulations consider these to be older than twenty years. Expanding the radius to 2640 feet (1/2 mile), 83 tanks are within the circle, of which 42 are 20 years or older and 20 are of unknown age. According to an EPA study, tanks 20 years and older have a 57 percent chance of leaking, so it appears there is a significant public-health risk to the three public wells in this area.

Further, the investigation of spills and leaks indicates that 43 percent of all such incidents were due to leaking underground storage tanks and all six of the confirmed hazardous-waste sites are the result of petroleum-product contamination. A management strategy of close monitoring and scheduled removal of suspect tanks could greatly reduce the risk to the water supply in this zone. In addition, the numerous threats to groundwater quality in ZOC #1 warrant periodic water quality analysis of monitoring wells in between the public wells and upgradient sources of contamination. The public wells themselves should be tested regularly for a wide range of organic compounds.

The data collected for Barnstable's ZOC #1 was incorporated into the Geographic Information System (GIS) project described previously in Chapter 5. After the data was digitized, it was manipulated to evaluate the pollution-potential risk to the water quality at the public-supply wells. The GIS computerized database provided the means to ask many "what if.." questions - a burdensome task otherwise. While the land-use survey described in this chapter was an essential step, the GIS project enabled a more sophisticated assessment of this information in risk assessment analysis than would have been possible otherwise (see CCAMP GIS Demonstration Project Report).

6.5.2 Management Issues

Of the several local, state, and federal programs examined, five emerged as having the strongest potential groundwater protection measures. These are the local toxic- and hazardous-materials bylaws in Barnstable

and Yarmouth, DEQE's Groundwater Discharge Permit Program, and the Commonwealth's Hazardous Waste Manifest and Underground Storage Tank Programs. Each of these management programs, as described in Table 6.1, provides incomplete protection to the groundwater resource. However, when all are well implemented, they may provide a strong framework for a comprehensive wellhead protection program.

Local and State Coverage of Hazardous Materials (See Appendix N)

Two major programs, the Hazardous Waste Manifest Program and the local Toxic and Hazardous Materials bylaw regulate hazardous materials and wastes. The state and federal emphasis is on waste generation, transport, storage, and disposal. The local emphasis is on storage of both wastes and virgin materials, business practices, drainage, and on ensuring compliance with applicable state regulations. The health agent's inspections are a crucial element in bringing commercial businesses into compliance with all of the relatively new programs that have emerged in recent years and in working practically to make sure that the costs for small-quantity generators are not so exorbitant that they fail to comply. The local bylaw does not duplicate but supplements the state program. It also serves to fill in certain gaps left by the state program. For example, antifreeze is only regulated at the local level.

Implementation of Local Hazardous Materials Controls

The toxic- and hazardous-materials bylaw, essentially the same in Barnstable and Yarmouth, provides an important frontline of defense against groundwater contamination. Since most of ZOC #1 is within the town of Barnstable, the following analysis focuses primarily on Barnstable's implementation of its bylaw. The bylaw requires all businesses to register any of the toxic and hazardous materials stored on their premises above the specified threshold and listed on the Toxic and Hazardous Materials Registration Form. These completed registration forms which list the various types of toxic and hazardous materials (Figure 6.4), local knowledge, complaints and wellhead-protection area boundaries guided the Barnstable inspection program.

Over 250 inspections were conducted by a health agent in Barnstable during the fall and winter of 1986 and 1987 (Figure 6.5). Without the Board of Health inspections, a number of these firms would not have been inspected at all. The inspection program also provides an effective means of educating area businesses regarding applicable regulations at the state and local level. The focus of these inspections is on the proper storage of hazardous materials, a primary enforcement concern for the town. The town bylaw requires that a containment structure and roofing be provided for any tank or drum stored outdoors. Its successful implementation has clearly made a difference in the business practices at a host of facilities. Recent inspections led to the discovery of over 2,000 gallons of toxic and hazardous materials improperly stored at several businesses townwide (Leitner, 1987). The inspections have also been crucial in educating business owners, discouraging improper business practices and providing referrals to DEQE regarding violations of state regulations.

TOXIC AND HAZARDOUS MATERIALS REGISTRATION FORM

NAME OF FIRM:

MAILING ADDRESS:

TELEPHONE NUMBER:

CONTACT PERSON:

Does your firm store any of the toxic or hazardous materials listed below, either for sale or for your own use, in quantities totalling, at any time, more than 50 gallons liquid volume or 25 pounds dry weight? YES__________ NO__________

This form must be returned to the Board of Health regardless of a YES or NO answer. Use the enclosed envelope for your convenience.

If you answered YES above, please indicate if the materials are stored at a site other than your mailing address:

ADDRESS: ______________________________

TELEPHONE: ______________________________

LIST OF TOXIC AND HAZARDOUS MATERIALS

The Board of Health has determined that the following products exhibit toxic or hazardous characteristics and must be registered when stored in quantities totalling more than 50 gallons liquid volume or 25 pounds dry weight. Please put a check beside each product that you store:

_____ Antifreeze (for gasline or coolant systems)
_____ Automatic transmission fluid
_____ Engine and Radiator flushes
_____ Hydraulic fluid (including brake fluid)
_____ Motor oils/waste oils
_____ Gasoline, Jet fuel
_____ Diesel fuel, Kerosene, #2 heating oil
_____ Other petroleum products: grease, lubricants
_____ Degreasers for engines and metal
_____ Degreasers for driveways & garages
_____ Battery acid (electrolyte)
_____ Rustproofers
_____ Car wash detergents
_____ Car waxes and polishes
_____ Asphalt & roofing tar
_____ Paints, varnishes, stains, dyes
_____ Paint and lacquer thinners
_____ Paint & Varnish removers, deglossers
_____ Paint brush cleaners
_____ Floor & Furniture strippers
_____ Metal polishes
_____ Laundry soil & stain removers (including bleach)
_____ Spot removers & cleaning fluids (dry cleaners)
_____ Other cleaning solvents
_____ Bug and tar removers
_____ Household cleansers, oven cleaners
_____ Drain cleaners
_____ Toilet cleaners
_____ Cesspool cleaners
_____ Disinfectants
_____ Road Salt (Halite)

_____ Refrigerants
_____ Pesticides (insecticides, herbicides, rodenticides)
_____ Photochemicals
_____ Printing Ink
_____ Wood preservatives (creosote)
_____ Swimming Pool chlorine
_____ Lye or caustic soda
_____ Jewelry cleaners
_____ Leather dyes
_____ Fertilizers (if stored outdoors)
_____ PCB's
_____ Other chlorinated hydrocarbons, (inc.carbon tetrachloride)
_____ Any other products with "Poison" labels (including chloroform, formaldehyde, hydrochloric acid, other acids)
_____ Other products not listed which you feel may be toxic or hazardous (please list):

____

____

____

Figure 6.4 Barnstable Board of Health Toxic and Hazardous Materials Registration Form.

TOWN OF BARNSTABLE
BOARD OF HEALTH

COMPANY ______________________

ADDRESS ______________________

COMPLIANCE:
- satisfactory
- unsatisfactory- (see "Orders")

Class: ________

CLASS:
1. Marine, Gas Stations, Repair
2. Printers
3. Auto Body Shops
4. Manufacturers
5. Retail Stores
6. Fuel Suppliers
7. Miscellaneous

QUANTITIES AND STORAGE (IN=indoors; OUT=outdoors)

MAJOR MATERIALS	Case lots			Drums			AboveTanks			Underground Tanks		
		IN	OUT		IN	OUT		IN	OUT	# & gallons	Age	Test?
Fuels: Gasoline, Jet Fuel (A)												
Diesel, Kerosene, #2 (B)												
Heavy Oils: waste motor oil (C)												
new motor oil (C)												
transmission/hydraulic												
Synthetic Organics: degreasers ______												
______												
______												
Miscellaneous: ______												
______												

DISPOSAL/RECLAMATION

1. Sanitary Sewage
   - Town Sewer
   - On-site
2. Water Supply
   - Public
   - Private
3. Indoor Floor Drains: YES____ NO______
   - Holding tank: MDC___
   - Catch basin/Dry well
   - On-site system
4. Outdoor Surface drains: YES____ NO____
   - Holding tank: MDC____
   - Catch basin/Dry well
   - On-site system

REMARKS:

ORDERS:

5. Waste Transporter

	Name of Hauler	Destination	Waste Product	Licensed? YES	NO
1.					
2.					

12 23 81 Person(s) Interviewed ______ Inspector ______ Date ______

Figure 6.5 Barnstable Board of Health Toxic and Hazardous Materials Inspection Form.

The lack of intertown coordination in WHP management is evident within this local program. Barnstable focuses the implementation of its bylaw on its ZOCs and Yarmouth approaches its local program the same way. Thus, there is very little local information available in the portion of the study area which lies within Yarmouth. A regional presence which encourages a joint management approach to the shared resource could be extremely important. The regional planning agency could identify wellhead-protection areas which cross jurisdictional boundaries and provide a forum for intertown cooperation and communication (see Chapter 7 for a discussion of regionalism).

Unfortunately the local bylaw is not being fully utilized at the state level. Many of the cases referred by local health boards for enforcement under state regulations are not responded to in a timely manner and enforcement support requested of the state is not always provided. DEQE should make a strong effort to develop a better working relationship with local boards of health. The agency should rely to some extent on local inspections to note violations at facilities which DEQE personnel would not have had time to visit. In turn, the state should provide local officials with enforcement and other support.

<u>The Hazardous Waste Manifest Program</u>

The Massachusetts Hazardous Waste Manifest Program (310 CMR 30) attempts to track hazardous wastes generated by businesses in amounts over twenty kilograms per month from their source of origin to their ultimate disposal site. These businesses include relatively small establishments such as dry cleaners and printers. Considering the newness and complexity of the program, it is evident that a major effort has been made by DEQE to increase small-quantity generator (SQG) awareness and compliance with the regulations. EPA's and DEQE's joint administration of the program has focused on the licensing of all hazardous-waste haulers. This effort has been particularly effective because it is now virtually impossible to have hazardous waste hauled from Cape Cod by an unlicensed hauler. In Barnstable, the health agent has also proved to be an invaluable resource in educating business owners and in distributing application forms for EPA notification numbers.

<u>The Management of Waste Transport</u>

The Hazardous Waste Manifest Program and the local toxic and hazardous materials bylaws place new requirements on businesses to properly store, and transport toxic wastes to secure disposal facilities. One of the major issues in trying to implement these bylaws has been that of economics. Prices for hauling waste oil, the least expensive material, may range as low as $.30/gal., but are generally between $.50- $1.00/gal. Other wastes are more difficult to dispose and more expensive to haul.

In Barnstable, the BOH has taken advantage of these costs by encouraging very small quantity generators to pool their wastes for transport. They have been quite successful in coordinating businesses of the same type to join together in transporting small quantities of waste to create

economies of scale. For example, the BOH has organized a battery recycling drop off day with the cooperation of a local automotive business. Fifteen businesses brought in approximately 500 batteries and were then required to set up an exchange program to prevent such an accumulation in the future.

While the BOH's approach has been quite successful, it would not be as effective in a less developed area where there may only be one printing or dry cleaning business in town. In this case, the networking of several neighboring towns should be pursued for the hauling of waste for each type of business. Regional planning agencies (RPAs) or health departments should have an important role in setting up these hauling pools by working through professional business associations and labor unions. DEQE and EPA should encourage and fund regional planning agencies to inventory these activities and to develop appropriate programs to respond to these needs.

The Groundwater Discharge Permit Program (See Appendix M)

DEQE has concentrated implementation of the Groundwater Discharge Permit Program on municipal wastewater treatment and other large-volume domestic wastewater flows and on those who voluntarily apply for permits. This program leaves commercial facilities at the low end of the priority scale. For example, only one industrial and four domestic groundwater discharge permits have been issued in ZOC #1. Out of 141 businesses meeting the threshold quantity information on the toxic and hazardous materials bylaws, 48 do not have EPA manifest notification numbers, are not sewered, do not have tight underground storage tanks (USTS) and are not covered by the groundwater permit program.

This poses the question of how these 48 businesses are disposing of their wastes. Although some of these firms may not discharge their wastes because they have unregulated tight tanks and mechanically contain their waste, a portion probably do discharge wastes directly to septic systems. These 48 businesses are good candidates for an inspection by DEQE staff because there is a good potential that a number of these facilities are discharging wastes illegally.

The groundwater discharge permit program is a very powerful yet under utilized groundwater protection tool. This program permits the regulators to provide businesses with the incentives, through permit issuance and denial, to change improper waste-disposal practices. Currently, DEQE's Division of Water Pollution Control (DWPC) does not have adequate resources to aggressively implement this program and pursue the existing backlog, as well as investigate cases in wellhead-protection areas. Thus, a host of commercial businesses that may be discharging industrial wastes directly to septic systems in close proximity to public-supply wells are being neglected. DWPC staff should utilize existing data, referrals, local BOH priorities and wellhead-protection area boundaries to target their inspections and enforcement activities.

Control of Underground Storage Tanks

As highlighted in the "Findings" Section and Tables 6.2, 6.3, and 6.7, the potential for groundwater pollution from petroleum products in ZOC #1 is a major continuing threat. Strong protective measures are crucial for preventing future contamination incidents.

The Department of Public Safety regulations provide the overall framework for tank control in Massachusetts. However, these regulations do not address the problem of tanks in close proximity to public-supply wells, control of aging tanks, and control of exempted residential fuel oil tanks. The Barnstable County Health and Environment Department recommends that Cape Cod towns adopt its model bylaw to fill in some of these program gaps. This model bylaw requires tank registration, tightness testing for USTS exempt under the state regulations, and mandatory UST removal after 30 years.

State regulations place primary UST responsibility with the local fire districts. Barnstable has several fire districts which are under the control of each district as well as a local bylaw which gives some authority over USTs to the BOH. The appointment of an UST coordinator could alleviate some of the resulting fragmentation. Such an individual could provide a leadership role at the local level and encourage data sharing and utilization in land use decision making.

6.6 Conclusions

Several changes in groundwater management, at all levels of government, must take place before a wellhead-protection approach can be fully institutionalized. Data must be maintained in an easily usable form and should be utilized by decision makers in all programs affecting groundwater quality, especially those involved with local zoning and land-use planning. There must be improved coordination of information, program responsibilities, and enforcement between and among levels of government. The results of such coordination are documented in the success of the hazardous waste manifest program. These changes will require new commitment and effort from all involved agencies. The results will lead to a strong and focused groundwater management program.

The results of this study document the high risk posed to groundwater by existing land uses. Protection of a highly developed zone, such as the Barnstable ZOC #1, must focus on implementation of programs regulating existing activities and on increased monitoring of groundwater quality. Less developed zones may be afforded protection through sound land-use planning. Even with strong groundwater controls in place, it is possible that the wells in ZOC #1 might become contaminated in the future. While the groundwater management goal is to prevent contamination, it is possible that wellhead treatment of contaminants may have to be considered in the future.

CCAMP observed that management of the major threats to the resource is limited by poor program implementation and a lack of communication between

and among different levels of government. The Groundwater Discharge Permit Program was identified as a program requiring improved implementation. However, none of the regulatory programs examined were in full compliance with their requirements.

The inventory results indicate that responsibilities for comprehensive groundwater protection fall primarily on localities. Local bylaws, regulating underground storage tanks and toxic materials storage, were found to be critical in filling the regulatory gaps of state programs and maintaining an awareness within the community of the need for groundwater protection. These new responsibilities will increase the strain on existing resources. However, regional planning agencies and the state may relieve this strain by coordinating with local governments, providing technical assistance and strengthening existing programs. RPAs have the opportunity to play an active role in coordinating hazardous-waste disposal and in encouraging joint management of wellhead-protection areas which cross town boundaries.

CHAPTER 7

INSTITUTIONAL RECOMMENDATIONS

7.1 Introduction

The Institutions Committee examined regulatory and non-regulatory programs that impact groundwater quality. The Committee examined laws, regulations, and policies and their implementation in the study area. Officials from a variety of different agencies and boards were interviewed for essential background information. The Committee also drew on the results of the land-use study (see Chapter 6) for information on program implementation. Using these sources and the knowledge and diverse experience of the committee members, recommendations were made to strengthen the protection afforded to groundwater within existing programs and to improve program consistency and coordination among levels of government.

The full text of each set of recommendations is contained within the Appendix. These cover the following topics:

- Water Supply Planning
- Landfills
- Private Wells
- Underground Storage Tanks
- Septage and Sludge
- Septic Systems
- Construction Grants
- Groundwater Discharge Permits
- Groundwater Classification
- Toxic and Hazardous Materials
- Pesticides

Refer to each recommendation for a detailed discussion on each of the above topics. This chapter will present only the main points.

7.2 CCAMP Recommendations for Improved Program Implementation

7.2.1 Water-Supply Planning (See Appendix H)

CCAMP participants identified a critical need to coordinate and better understand the relationships between water-supply planning and waste water planning at the local and state levels. In attempting to site a waste water treatment plant, it is essential that both the town and the DEQE understand the relationship of the proposed site to both current and future water supplies, and ensure that actions taken will not interfere with long-term water supply development. Many municipalities have not adequately planned for their future water supply needs. This is an absolutely critical first step in any groundwater management program or in any attempt at land-use planning.

For the most part, water-supply planning is absent in towns that currently have no public-water supplies. These towns rely solely on private wells and therefore do not have the knowledgeable water-supply personnel

to articulate the need for this kind of planning and initiate action. DEQE should initiate an aggressive outreach and loan program to promote water supply planning in towns with no public water through planning grants and greater technical assistance. DEQE/DWS should also set up a grant program for assistance to communities for Zone II delineation. Finally, DWS should utilize the new source approval process to educate local officials on Zone II protection and to exert some control on inappropriate land uses in these areas.

7.2.2 Enhanced Groundwater Protection in Landfill Programs (See Appendix I)

CCAMP reviewed landfills at a time when the DEQE Solid Waste Program was emerging from four years of limited staffing and low program ranking. As a result, protecting groundwater from landfill leachate and incorporating a groundwater protection strategy within the overall solid-waste program was woefully lacking at the state level, where primary regulatory authority lies. Particularly troublesome was the inadequate or nonexistent groundwater monitoring at landfill sites. Key CCAMP recommendations for landfills include:

- Impacts to public- and private-water supplies should be the first priority of DEQE's landfill management program. A prioritized ranking system should be established and implemented to drive all landfill activities: siting, plan review, monitoring, inspection, capping, closure and enforcement.

- No landfills should be sited in Zone IIs of public water supplies. Existing landfills in Zone IIs should be phased out as soon as possible.

- DEQE should establish a well-defined, comprehensive landfill monitoring program. All landfills in the state should be required to install adequate groundwater-monitoring systems.

- DEQE and local authorities should develop a workable system for sharing information and data on all groundwater monitoring conducted at landfills to better assess threats to drinking water supplies.

7.2.3 Private Wells (See Appendix J)

Following an evaluation of the needs to protect private wells in the towns of Barnstable and Eastham, CCAMP recommended that both county and state agencies immediately take steps to develop guidance documents for use by homeowners and local officials for the protection of this resource.

At a minimum, information should be provided as:

- An information brochure for use by private well owners. This document should be developed by the Barnstable County Health and Environment Department and the Cape Cod Planning and Economic Development Commission.

- A guidance document for use by local boards of health and other appropriate boards. This document should be developed by DEQE and include such information as model bylaws, a techical appendix of useful information such as geological and chemical factors affecting private-well-supply protection.

7.2.4 Underground Storage Tanks (See Appendix K)

CCAMP found that underground storage tanks (USTs) are one of the most serious, and most prevalent threats to groundwater quality on Cape Cod. The major problems observed were the large number of aging, leak-prone tanks and the large number of tanks in close proximity to private- and public-water supplies. Local communities must utilize land-use controls, UST bylaws or aquifer protection district zoning to discourage USTs in sensitive well recharge areas. In addition, towns must adopt bylaws to protect and inventory all tanks including those exempt from the registration and testing requirements of the state regulations. To coordinate the town program and ensure that tank data is shared and utilized, municipalities should appoint an UST coordinator. The state must provide guidance on tank cleaning and disposal. All levels of government have important roles to play in providing sorely needed public education.

7.2.5 Septage and Sludge Management (See Appendix L)

Cape Cod has a very serious septage management problem that is jeopardizing groundwater quality from one end of the peninsula to the other. Progress toward establishing long-term septage treatment facilities has been very limited for over a decade. Currently, 69 percent of the septage generated on the Cape is disposed of in septage pits or lagoons that do not afford adequate treatment before the waste is returned to groundwater. DEQE should continue to bring enforcement action against these illegal disposal areas. This will encourage towns to plan for their future septage-disposal needs. EPA, DEQE and regional planning agencies must cooperate to encourage regional solutions to septage disposal problems. Planned regional facilities should then receive the full attention of the construction grants staff through a "fast track" process which expedites projects.

A Residuals Unit was recently created within DEQE to work on issues involving septage and sludge disposal. CCAMP applauds this as recognition of an area that has been neglected statewide for years. This Unit should be given the appropriate resources to deal with residuals issues in a comprehensive way. In particular, the Department must develop, as soon as

possible, a sludge management program and must examine the issues involving the composting of septage sludge.

7.2.6 Septic Systems (See Appendix L)

The State should actively pursue amending Title 5 of the State Environmental Code which governs septic systems to enable more effective regulation of contaminants that are not being adequately addressed, particularly nitrogen and synthetic organic compounds. Special emphasis must be placed on conducting the necessary research so that adequate guidelines can be developed for the proper siting of septic systems relative to private wells, surface water bodies and wetlands. Management of Title 5 at the local level requires substantial improvement. Health agents and boards of health must upgrade the level of expertise for program administration, in addition to adding more staff. DEQE should provide yearly training in the Title 5 program, and ultimately devote one position in each regional office to serve as a coordinator and technical assistance liaison.

7.2.7 Construction Grants (See Appendix M)

The Massachusetts DEQE Division of Water Pollution Control (DWPC) has primary responsibility for granting funds to construct wastewater treatment plants, as well as determining the acceptability of the chosen location, and the level of treatment required. This is especially difficult on Cape Cod because all supply wells are groundwater fed and any land discharge must consider possible impacts. Furthermore, state law (the Ocean Sanctuaries Act) prohibits any new discharges to the waters surrounding Cape Cod. The construction grants process must respond to the serious environmental problems on the Cape by putting more effort into the facilities planning phase and working more closely with the towns and the consultants to move the program along. RPAs should become directly involved in working with towns to promote regional solutions. The local governments themselves must take more of a leadership role in working to solve their communities' wastewater-management problems.

7.2.8 Groundwater Discharge Permits (See Appendix M)

DEQE's Groundwater Discharge Permit Program, administered by the DWPC, regulates ground discharges of domestic wastewater greater than 15,000 gpd and industrial discharges to the ground in any quantity. It has the potential to be an extremely powerful groundwater protection program but it has been underutilized by DEQE and lacks the resources to carry out its mission. As a result, numerous sources of domestic and industrial groundwater discharges remain unregulated on Cape Cod. Entire categories of small businesses may be discharging toxic contaminants to septic systems illegally. DEQE must considerably increase the resources available to this program for regulating these commercial and industrial waste discharges.

Local boards of health can be very helpful in identifying for the state the businesses and land-use activities that are discharging toxic and hazardous materials without a permit. This is especially important if they are within the recharge area of a public supply well. The towns should inventory all potential sources of contamination (i.e., categories of businesses or land-use activities that use or produce especially harmful chemicals) within wellhead protection areas to assure they are adeqately controlled. This will serve as an important complement to the state program.

7.2.9 Groundwater Classification (See Appendix M)

DEQE's groundwater classification system is incomplete without the inclusion of a limited anti-degradation provision within vulnerable groundwater-recharge areas. The Department should actively pursue this policy change. In addition, CCAMP supports the stringent review process for the designation of Class III (degraded) areas and would oppose efforts to weaken the current procedures. Finally, classification and permit determinations made by the Division of Water Pollution Control should elicit the comments of the Division of Water Supply to ensure a thorough review of possible impacts to current and future water supplies.

7.2.10 Hazardous Materials Use and Storage (See Appendix N)

The large and growing number of businesses that generate small quantities of hazardous waste on Cape Cod, coupled with the vulnerability of the aquifer system, make aggressive regulation of the use, storage and disposal of hazardous materials a priority. Fully embracing a comprehensive approach to hazardous-waste management and resource protection will necessitate broad management changes. As a first step towards change, CCAMP developed recommendations aimed at improving groundwater protection by increasing the emphasis in hazardous waste regulation and focusing on prevention, planning, education and coordination among state, regional and local levels.

To encourage compliance from small-waste generators, DEQE must look beyond its strictly defined regulatory role and coordinate with Department of Environmental Managment (DEM) and its Office of Safe Waste Management (OSWM) to engage in outreach, education and planning. The state should provide technical assistance to small businesses and should encourage and fund regional agencies to sponsor outreach programs, hazardous-waste-collection routes, and household-waste collections. The state should also ensure that attention is focused on waste exchange, source reduction and the creation of economic incentives or markets for hazardous waste.

DEQE should initiate a pilot program in the Southeast Regional Office to conduct facility inspections jointly across DHW and DWPC programs. This approach would foster more efficient and environmentally sound business practices. An operator would consider the various components of his

waste stream as a whole and try to reduce the waste generated and then dispose of it properly in a cost-effective manner.

Many towns do not have available resources or expertise to develop programs to inspect local businesses using hazardous materials. The Barnstable County Health and Environment Department (BCHED) should procure funding for regional inspectors specializing in hazardous materials to loan to those towns in need, as is currently practiced with county sanitarians.

All levels of government have a role to play in ensuring that private wells are tested for synthetic organics in high risk areas where contamination is suspected. BCHED and CCPEDC should cooperate in identifying high risk areas on Cape Cod and should design a sampling program to test these wells on a periodic basis.

7.2.11 Pesticides (See Appendix O)

At the current time, CCAMP has determined that very little useful information is available concerning this class of chemicals related to specific land-use categories found on Cape Cod.

Despite the absence of data which shows that pesticides pose a public-health risk from turf management and agricultural use of these chemicals, it is recommended that more research and information should be collected by appropriate federal, state and county agencies, including:

- o Environmental fate (mobility) studies of commonly used pesticides
- o Rank pesticides according to their environmental fate and toxicity and review all registrations on the basis of this information.
- o Determine the toxicity of pesticides alone or in combination to determine the synergistic effects of two or more chemicals.
- o Increase the visibility of the The Department of Food and Agriculture's Pesticide Bureau, the state's regultory enforcement agency, through the development of regional offices.
- o Implement a program to spot check private wells for pesticides in common use.
- o Continue the interagency task force to coordinate response to water-supply and public-health issues.

In the absence of this information and the proposed agency activities to implement changes, it will be important to implement these recommendations as necessary first steps before any local, state, or federal programs can develop the necessary bylaws, policies, or regulations for

protecting the environment and public health. The highly permeable geological conditions which favor the mobility of these potential contaminants requires that we all exercise due caution and control for mitigating any environmental- and public-health impacts that may arise from the use of these chemicals.

7.2.12 Road Salt

Elevated sodium concentrations are a major concern on Cape Cod. One public-supply well has been closed recently due to contamination from road salt use on a nearby highway. When CCAMP examined the topic of road salt in the winter of 1986-1987, the Department of Public Works announced a new policy for Cape Cod. Out of concern for public-water supplies, the Department of Public Works reduced the salt content of its road deicing mixture (4:1 sand to salt ratio instead of a 1:1 ratio) for state highways on Cape Cod with two heavily traveled exceptions. CCAMP applauds this policy change but believes that it should also be accompanied by a sodium monitoring program to document the impact of salt reduction on public--supply wells.

7.3 Appropriate Roles for Different Levels of Government

CCAMP initiated its study of this topic with the concern that all levels of government must better coordinate their groundwater protection efforts. At its conclusion, this same belief was even more firmly entrenched.

Groundwater is a particularly difficult resource to protect because of the number and variety of sources of potential contamination threats. Equally varied are the array of groundwater related regulations, laws, policies, land-use controls, and bylaws in effect to control groundwater contamination. No single level of government has full control over all of the sources of groundwater contamination. EPA estimated at the outset of the CCAMP project, that its programs address only one-third of the possible sources of groundwater contamination nationwide. The states and local governments cannot claim full authority over groundwater protection either. Clearly, coordinating the efforts at the federal, state, regional and local levels is the key to a comprehensive protection program. This must be done so that each level of government is charged with those responsibilities it is most capable of implementing. Table 7.1 lists and summarizes the major findings of the most appropriate groundwater protection responsibilities for each level of government.

7.3.1 Federal Role

The federal role in the protection of environmental resources involves a variety of activities including regulation, research, standard setting, technical assistance and funding. Unlike other media EPA regulates, there is no single statute which provides comprehensive authority over groundwater. The Wellhead Protection Program established with the passage of the Safe Drinking Water Act Amendments in 1986 provides EPA with the first

TABLE 7.1

KEY CCAMP RECOMMENDATIONS

SELECTED MAJOR FINDINGS	LOCAL LEVEL	REGIONAL LEVEL	STATE LEVEL	FEDERAL LEVEL
1. Utilize resource-based approach to groundwater management	- Discourage the location of USTS in wellhead protection areas (WHPs); replace old tanks in these areas. - Plan for future water supplies; adopt zoning bylaws to protect areas for future supplies	- RPAs should encourage joint management of WHPs crossing town boundaries - RPAs should designate regional areas of critical planning concern (such as WHPs) and comment on proposed development in these areas.	- Provide loans to communities for delineating wellhead areas - Specify stricter construction standards for USTS and piping in WHPs - No new landfills in WHPs - WHPs should guide enforcement priorities for DEQE programs - DEQE should provide technical assistance and loans for public water supply planning	- EPA should provide guidance on management of WHPs. - USGS should continue its detailed study of groundwater resources and disseminate results widely - EPA programs (RCRA, UIC, Construction Grants, UST) should set program priorities within WHPs - EPA should strengthen protection conferred by Sole Source Aquifer status
2. Inadequate groundwater monitoring at landfills	- Towns should examine current monitoring at landfill for adequacy. - Should initiate landfill monitoring programs. - Should test private wells near landfills.	- Encourage towns to develop monitoring programs and provide technical information - County lab on Cape tests water quality near landfills if town requests	- DEQE should develop landfill monitoring protocol and standards in new regulations. Should aggressively enforce. - Tie monitoring requirements to expansion requests	- EPA initiated landfill monitoring program at 4 Cape landfills--tested monitoring wells and private wells for VOCs, metals and nitrogen series; EPA should continue with this type of assistance

TABLE 7.1

KEY CCAMP RECOMMENDATIONS

SELECTED MAJOR FINDINGS	LOCAL LEVEL	REGIONAL LEVEL	STATE LEVEL	FEDERAL LEVEL
3. Inadequate planning for future water supply needs	- Towns should have a water study committee - Towns on public or private water should identify future sites for public wells - Towns should have a master plan - Towns should do a build-out analysis and population projections for water planning - Towns should map wells, Zone IIs, waste sources, future wells, etc. - Adopt aquifer protection bylaw to protect present and and future water needs - Should charge true cost of water; use revenues for water planning and protection.	- Technical assistance to communities on water supply planning - RPAs should foster cooperation between towns on management of shared Zone IIs - Model Aquifer Protection District Bylaw	- DEQE should initiate outreach and loan program targeted to towns dependent on private wells that will need public supplies. - Provide funding to these towns for water studies - Provide adequate incentives to towns for completion of water resource plans (i.e. grant eligibility) - DEQE should initiate a grant program to assist towns in Zone II delineation - State should require planning before zoning - DEQE should require appropriate protection measures for Zone IIs for new source approvals	- EPA should include water supply planning as part of studies funded by 201 wastewater planning monies where necessary

TABLE 7.1

KEY CCAMP RECOMMENDATIONS

SELECTED MAJOR FINDINGS	LOCAL LEVEL	REGIONAL LEVEL	STATE LEVEL	FEDERAL LEVEL
4. Inadequate expertise at local level to carry out technical programs including Title 5, water supply planning, and inspections of toxic and hazardous materials use, etc.	- Towns should hire adequately trained staff or share staff with neighboring towns - Towns should collect permit fees to be used to hire staff	- RPAs should educate local officials and provide training and technical assistance - RPAs should conduct workshops for towns on technical issues - BCHED should consider hiring trained inspectors to be lent to towns as needed for inspections of businesses using hazardous materials	- State should increase technical assistance provided to towns - DEQE should cooperate more with BOHs and provide locals more enforcement support - Develop educational materials - EOCD should expand its incentive aid program which pays for one or more towns to hire planners	- EPA should continue to target some federal monies to the regional level for technical assistance efforts - EPA and USGS should develop educational materials
5. Private wells are not afforded adequate protection (See #3)	- Control well construction, installation, abandonment - Encourage testing of private wells - Review Title 5 setbacks for distances from septic tanks and wells	- County laboratory should continue to provide low-cost testing of private wells - RPA should develop educational brochure for well owners - RPA should identify private wells in vulnerable areas (i.e. near landfills) that should be tested - CCPEDC and BCHED should initiate a testing program for these wells	- DEQE should develop guidelines and a model bylaw for well construction, installation and abandonment - Revise Title 5 setback requirements	- EPA and USGS should research effect of septic systems on private wells

TABLE 7.1

KEY CCAMP RECOMMENDATIONS

SELECTED MAJOR FINDINGS	LOCAL LEVEL	REGIONAL LEVEL	STATE LEVEL	FEDERAL LEVEL
6. Large number of aging underground storage tanks in close proximity to public water supplies	- Inventory and map tanks - Utilize land use controls to discourage new tanks in Zone IIs - Appoint UST coordinator - Adopt UST bylaw to regulate fuel oil tanks and encourage removal of tanks at specified age	- Educate local oficials and public - Transmit research findings to local level - BCHED assistance program for tank inventory - Model UST bylaw	- State should clarify existing policies on tank cleaning and disposal - Require stricter construction standards for tanks and piping in Zone IIs. - Develop educational materials	- Provide educational materials - Relay info on successful state and local programs - Research new tank construction and other technologies - Research causes of tank failure or leakage
7. Rapid growth rate on Cape Cod leading to high nitrogen loading and other problems	- Do build out analysis - Utilize CCAMP nitrogen loading formula in planning reviews to calculate future nitrate concentration at wellhead - Zone to ensure concentrations will not exceed planning goal of 5 mg/L. - Require Title 5 applicants to demonstrate that goal will not be exceeded - If needed, restrict fertilizer use - Towns should consider phasing growth so infrastructure needs can be met	- Technical assistance to communities on nitrogen loading formula application - RPA should develop regional growth plan; local plans should be consistent	- State should require planning for future water supplies before zoning - Require discharge permit applicants (>15,000 gpd) to demonstrate <=5 mg/L nitrate conc. at well - Revise Title 5 to incorporate density factor in the calculation - Encourage/fund wastewater treatment facilities with advanced levels of treatment	- Sponsor research on denitrification technologies - Encourage/fund 201 facilities with advanced levels of treatment for ground discharges within sole source aquifers - USGS should continue to research the relationships between land use and nitrate loading

TABLE 7.1

KEY CCAMP RECOMMENDATIONS

SELECTED MAJOR FINDINGS

	LOCAL LEVEL	REGIONAL LEVEL	STATE LEVEL	FEDERAL LEVEL
8. Small commercial businesses with potential impact on water supplies are not adequately controlled.	- Ensure proper drain design and appropriate DEQE permit before allowing building occupancy - Conduct an inventory of these businesses by town; concentrate in Zone IIs for towns on public water - Enforce pretreatment requirements in sewered areas. - Adopt toxics bylaws - Inspect facilities; educate owners; enforce bylaws - Hire professional staff	- Technical assistance to Boards of Health (BOH) - Model toxics bylaw - Organize registration of Small Quantity Generators - Coordinate hazardous-waste collections	- DEQE should drastically increase enforcement of groundwater discharge permit program - Develop joint DHW/DWPC inspection program to look at waste stream as a whole. - Provide guidance to BOHs on alternatives to floor drains - Utilize Zone II boundaries to set inspection priorities - Develop a strong state source reduction program - DEQE DHW/DSW and DEM OSWM should engage in outreach, education, and planning	- EPA should research cumulative risk to water supplies from a number of small sources. - USGS should enter into cooperative programs for hydrogeological research on risk associated with these sources - EPA should conduct research on non-hazardous product substitution and source reduction
9. Numerous septage pits and lagoons contaminating groundwater across the Cape (See #5)	- Towns should have a waste water study committee to ensure future needs are met - Should pursue a long-term solution (e.g. septage treatment plant) - Coordinate with neighboring communities	- RPA should encourage intertown cooperation towards regional solutions - Should transmit new research results to towns	- DEQE should continue aggressive enforcement against illegal pits and lagoons - Should ensure prompt consideration of above town's 201 construction grant applications - Improve coordination with towns throughout grants process - Promote regional solutions - Should research impacts of septage effluent	- EPA should continue to provide partial funding for construction of septage treatment facilities - EPA should ensure grant ranking systems to adequately consider groundwater threats - USGS and EPA should conduct research on new technologies and on groundwater contamination from septage

real opportunity to approach groundwater protection in a comprehensive manner. The federal role in this program is one of providing a framework and guidance to states and localities on the comprehensive management of wellhead areas. Wellhead protection provides a new challenge and opportunity for EPA to look at its own programs as well as to encourage comprehensive resource based management at other levels of government.

7.3.2 State Role

With no comprehensive groundwater protection program at the federal level, states have historically taken the initiative for developing and implementing their own groundwater protection programs. The Commonwealth of Massachusetts has developed a particularly aggressive approach to groundwater protection; characterized by a combination of regulatory controls and an emphasis on Zone II delineation and protection. Because of its major responsibilities, the state, particularly DEQE, bore the brunt of the majority of CCAMP's recommendations. At DEQE, as at EPA, the historic emphasis on surface water over ground water is evident, particularly in the Division of Water Pollution Control where a number of CCAMP's recommendations took particular aim. Other programs such as that for landfills also do not have groundwater concerns fully integrated into their program purpose and scope. It is hoped that through this across-the-board examination of groundwater issues, DEQE will pursue a comprehensive, agency-wide, groundwater program.

7.3.3 Regional Role

In Massachusetts, as in much of New England, county government has been limited by its lack of authority. On Cape Cod, the CCPEDC and BCHED fostered a strong local interest in groundwater protection, and managed to play a particularly important role in filling the gap between programs at the state and local levels. While lacking any enforcement authority, these two agencies managed to provide public education, laboratory resources and a variety of other technical services to towns. CCAMP has identified this regional role as extremely important and one that should be strengthened in bridging the state-local gap.

7.3.4 Local Role

The critical land-use decisions, with long-term implications for groundwater protection are made at the local level. Municipalities in Massachusetts, with a strong tradition of home rule have virtually complete control over local land use and zoning. Consequently, communities have particularly effective tools available to them that must be utilized more aggressively for future planning. Technical assistance, enforcement support, and educational outreach from other levels of government are desperately needed by local boards. Most importantly, towns must hire professional staff. Towns must also develop a master plan with consistent zoning for the protection of future water supply needs. See Appendix P for a discussion which outlines a planning process for use by towns to protect groundwater.

7.4 General Observations/Conclusions

7.4.1 Local Abilities

During the course of this project, CCAMP members have observed a clear lack of ability at the local level to adequately manage the intense development pressures created by overwhelming Capewide growth. The current institutional framework that leaves municipalities with the principal responsibility for making well-informed and effective land-use decisions is not working. Poorly sited and inappropriate land uses, whether landfills, septage lagoons, underground storage tanks or local businesses that utilize hazardous materials, threaten fragile groundwater supplies in all 15 Cape towns. This is compounded by the fact that groundwater resources and contamination sources do not respect town boundaries, as sources of contamination in one town are often found in the wellhead protection area of another town's water supply.

7.4.2 Lack of Comprehensive Land-Use Planning

Most Cape towns have allowed zoning determinations to precede planning decisions and now are facing the consequences of haphazard growth. By not first considering and identifying the resources for protection, towns have allowed zoning to proceed blindly with no master plan for resource protection. One of the best examples is the Town of Barnstable, where commercial zoning for its industrial park was established over the prime recharge area for several of its major public water supplies. Like Barnstable, most Cape towns have allowed zoning to proceed independently of protecting present and future water supplies. Unfortunately, this has put most Cape towns in the untenable position of being "programmed" for growth and beyond the capacity of their environmental infrastructure. Although much work has taken place recently to alter zoning through the establishment of groundwater-protection districts, this often results in a "catch up" effort that must deal with existing, non-compatible land uses.

Further impediments to comprehensive planning are the Massachusetts Zoning Act (Massachusetts General Laws (MGL) Chapter 40A) and the Subdivision Control Law (MGL Chapter 41) which make it very difficult for municipalities to change their zoning to reflect the recent environmental awareness and need to protect groundwater. A two-thirds vote at a Town Meeting is required to adopt or change a zoning bylaw. This process is extremely difficult due to the strength that special interests can generate at a Town Meeting. It has forced several Cape towns into promulgating public-health regulations (which do not require a town meeting) that establish specific resource protection measures in particular areas and situations. This Zoning Act contains many time clocks that place an undue burden on planning boards as they attempt to introduce zoning articles at Town Meeting. Most articles are defeated on a strictly procedural basis.

The Zoning Act also contains "grandfather" provisions that undermine attempts to make local zoning consistent with groundwater protection districts. The most severe is an eight year "grandfather" period allowed for subdivision plans. This permits a project up to eight years to be constructed under zoning bylaws in effect at the time plans were submitted. Despite the obvious problems with the Zoning Act, previous attempts to change it have usually resulted in a lengthening of the "grandfather" period rather than the reduction planners had sought.

7.4.3 Dearth of Technical Expertise at the Local Level

Most Cape Cod towns are severely handicapped in their efforts to implement local regulatory programs to protect groundwater because they lack the necessary personnel with the requisite technical expertise. Half the towns do not employ town planners and several do not maintain full-time health agents. Due to the wide range of disciplines required of any one town employee, even the towns that retain planners and health agents are hard-pressed to deal expertly with the many complex environmental issues. Technical expertise and professional staff are needed not only for planning and for implementation of Title 5 for on-site septage disposal but also to control a host of other land-use activities as briefly described in Chapter 6.

Many land uses are judged inappropriate for federal or state regulation because they are often too small to detect or too numerous to enforce. These activities must then be managed by local agencies or go unregulated. A graphic example are the numerous discharges that require state groundwater discharge permits, but have gone unregulated by an understaffed DEQE (see Appendix M and Chapter 6, section 6.5.2). The towns are thus on their own in attempting to regulate such things as: small-scale storage and disposal of hazardous substances; the siting and regulation of many commercial-land-use activities potentially harmful to groundwater quality; and high-density development in groundwater recharge areas. In sum, most land uses on Cape Cod fall outside the regulatory framework established by the lead state and federal regulatory agencies.

7.4.4 Importance of Technical Assistance

There are a wealth of talented professionals working in state, federal, and regional agencies who should extend their abilities to local government through outreach efforts. It is essential that DEQE, DEM and EPA develop and enhance programs that serve to educate and assist local land-use planners and managers. The USGS is also invaluable in its role of transferring technical information for utilization at the local level. Regional planning agencies such as CCPEDC are ideally suited to serve as conduits between state and federal agencies and the local level. Such an outreach effort would ensure that information is conveyed properly and delivered to the appropriate agency or board. Many of CCAMP's recommendations (Appendices H-O) contain specific suggestions concerning outreach in various areas.

7.4.5 Creation of a Regional Land-Use Regulatory Agency

The current institutional framework that leaves municipalities with the principal responsibility for making well-informed decisions and effective land-use decisions is not working. Transferring good technical information to the local level is very important, but it only represents a partial solution. A truly comprehensive approach that treats groundwater as a regional resource and goes beyond the planning stage, is also required.

The creation of a regional land-use agency with the necessary regulatory authority to help manage the ongoing land-use crisis on Cape Cod is a viable approach. Such a regulatory body would serve to better control land uses, and hence more fully protect groundwater. The major features of such an approach include the following: (1) solidly-based comprehensive planning would be mandated Capewide, treating groundwater as a regional resource that does not respect town boundaries; (2) the State Zoning Act and Subdivision Law that heavily favor development interests would be tempered, primarily through neutralization of "groundwater" provisions; (3) technical expertise would be centralized at the regional level and would be utilized more efficiently and consistently to supplement local technical deficiencies in the development of scientifically-based groundwater protection rules.

<u>The Cape Cod Commission.</u> Special state legislation has been proposed for Cape Cod that would create a regional land-use regulatory agency called the Cape Cod Commission (CCC), under the auspices of CCPEDC. It evolved through a "grass roots" effort called "Prospect: Cape Cod" that sought to envision what the Cape should be like five years from now (CCPEDC, 1987). The CCC is modelled after the Martha's Vineyard Commission, an existing regional land-use regulatory body. Borrowing from the Vineyard example, the CCC would retain authority over Districts of Critical Planning Concern (DCPC) and Developments of Regional Impact (DRI). DCPCs are designated areas that require special protection because of their public-health, ecological, recreational, historical, cultural, or aesthetic value and importance. Using a groundwater example, this would allow the regional body to regulate projects within zones of contribution to public supply wells (which would most likely be designated as DCPCs). DRIs are developments that should be reviewed by the regional authority due to their greater-than-local impact. An example of this could be a proposed waste water treatment plant in one town, that would affect private wells in an adjacent town.

CHAPTER 8

PROJECT EVALUATION

The success of the Cape Cod Aquifer Management Project must continue to be evaluated in the coming years as the implementation of many of the project's recommendations proceeds. Experience with the methods suggested by CCAMP will shed light on their effectiveness. However, at this point it may be useful to others contemplating cooperative groundwater projects in the future to discuss some observations.

CCAMP was successful in two major ways:

1. Specific cooperative projects aimed at demonstrating or investigating groundwater protection methodologies (GIS project, land use study, nitrate loading model, etc.).

2. An institutional examination of groundwater protection which led to the development of detailed recommendations to strengthen groundwater protection at all levels of government.

CCAMP's mission was broad - to develop new ways of protecting groundwater based on the characteristics of the resource itself. Such a charge necessarily involves the two aspects discussed above, but integrating these approaches in a single project can be difficult, as is meshing the goals of different agencies.

CCAMP's committees each had a long learning curve, first beginning to identify issues for their examination. While it would have been effective and would have improved project integration if a central committee had identified key issues and defined project goals at the outset, the process of education and issue identification was an extremely valuable one. It also would have been helpful to sequence work assignments with the Aquifer Assessment Committee for initiating the project and to identify key issues and information needs for the Data Management Group. The Institutions Committee would then have had the work of these two groups to draw on in its examination of the institutional deficiencies in groundwater protection.

The project was an extensive one for one full-time person and committee members, all with competing work commitments, to undertake. A core group of full-time staff, one from each agency and an intern, reporting to the committees, would have increased the ability to investigate issues and develop solutions in a shorter time period. A project manager with the responsibility to direct the project and make key decisions would also have helped. The lack of money for research also added uncertainty to the group's agenda but CCAMP was able to find money for special efforts such as the GIS project or the wellhead-protection guide.

CCAMP still requires a well conceived implementation strategy for its recommendations. Each agency is now handling the implementation of the recommendations dealing with its own policies. CCPEDC is responsible for

transmitting many of the local recommendations to Cape communities and has begun to pursue CCAMP findings through work with the towns of Chatham, Truro and Provincetown. But no standard exists for measuring the success of implementation efforts and no timetables have been set. Implementation is an absolutely critical piece of this project; a clear implementation strategy should have been developed at the project's initiation.

One of CCAMP's most important, least tangible, successes was in initiating a joint, interagency, multi-level approach to groundwater protection. Each agency enjoyed real benefits from a close working association between its staff and those of other agencies in terms of information exchange, technical support, valuable future contacts, and insights into another side of a particular issue. Because project participants are in-house staff, not outside consultants, the institutional knowledge gained can contribute on an ongoing basis in other areas. These associations with other agency staff also led to a number of cooperative spin-off efforts.

While stressing that coordination and communication were key benefits of the project, it must also be noted that input and participation from the local level was insufficient. There should have been regular participation of CCAMP committees with local officials in other communities on particular topics. A greater degree of local involvement throughout the project would. also facilitate local implementation of CCAMP recommendations.

8.1 <u>CCAMP's Future Directions</u>

At the close of the CCAMP project, the emphasis of the participating agencies will turn towards the implementation of CCAMP's recommendations and to transmitting project findings to other areas that might benefit. Agencies should also upgrade the focus in their groundwater programs on public-outreach and intergovernmental-cooperative efforts based on CCAMP's observations. There are also a number of issues that CCAMP identified as important but was not able to address or could not address thoroughly. These might become the topics of future projects. These include:

1. More work on the relationship between private-well drinking water quality and septic systems. A methodology should be developed to protect private wells through siting or other mechanisms.

2. An analysis of the economics of the issues covered by CCAMP.

The costs associated with the implementation of groundwater-protection programs should be determined. Cost figures would be helpful in weighing alternative approaches and in appropriately estimating the resources needed for implementation. A study should also be initiated investigating

the costs and benefits of protective groundwater controls versus both remediation of contaminated sites and treatment at the wellhead.

While the goal of the CCAMP effort is to protect groundwater and to avoid the need for remediation and treatment; there will always be cases where treatment may be a necessity.

8.2 CCAMP's Challenge

The completion of CCAMP's study phase, as described in this final report and the technical reports and journal articles published elsewhere, represents the challenge facing CCAMP: the implementation of CCAMP's recommendations. CCAMP has now assembled the facts and has the basis for implementing change at all levels of government for the protection of the Cape's sole-source aquifer. CCAMP has succeeded in defining its future goals and in developing the framework for the cooperative interagency approach that will be necessary to enact these important changes. The limited resources available to the project for implementing these recommendations have not changed. It will therefore be necessary for each CCAMP agency to implement those recommendations that pertain to it and to work together in coordinating interagency efforts having the highest priority.

CCAMP's ambitious goal of changing the way federal, state, regional and local agencies approach groundwater was extremely successful. The project succeeded in demonstrating that all levels of government can work together around a common goal. Changes will come slowly. However, a blue print is now in place for establishing a sound basis for improving the way each level of government can protect this vital resource.

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APPENDIX A

CAPE COD AQUIFER MANAGEMENT PROJECT PARTICIPANTS
AND PROJECT STRUCTURE

Steering Committee

Armando Carbonell	Executive Director, CCPEDC
Michael Frimpter	Chief, Massachusetts Office, USGS
Meriel Hardin	Assistant Commissioner for Special Projects, DEQE
Gilbert Joly	Regional Environmental Director, DEQE, Southeast
Michael MacDougall	Chief, Information Management Branch, EPA
Robert Mendoza	Director, Office of Ground Water Protection, EPA
Bruce Rosinoff	Senior Staff Advisor, CCPEDC

Tara Gallagher	Project Coordinator, DEQE

Institutions Committee

Chairperson: Bruce Rosinoff, CCPEDC

Armando Carbonell	CCPEDC
Tara Gallagher	DEQE
Meriel Hardin	DEQE
Gilbert Joly	DEQE/SERO
Robert Mendoza	EPA/OGWP
Susan Nickerson	CCPEDC
Beatrice Nessen	DEQE/DSW
Mark Pare'	DEQE/DWPC
Bruce Rosinoff	CCPEDC/EPA
Lee Steppacher	EPA/OGWP
David Terry	DEQE/DWS

Data Management Committee

Chairperson: Michael MacDougall, EPA

Gabrielle Belfit	CCPEDC
Roy Crystal	DEQE/DWS
Robin Fletcher	EPA/IMB
Tara Gallagher	DEQE
Ethan Mascoop	EPA/IMB
Margaret Nelson	EPA/Library
Lee Steppacher	EPA/OGWP
Nancy Wrenn	EPA/OGWP

Aquifer Assessment Committee

Chairperson: Michael Frimpter, USGS

Paul Barlow	USGS
Gabrielle Belfit	CCPEDC
Bill Bones	DEM/DWR
Eric Butler	BCHED
Jeffrey Chormann	DEQE/DHW
John Donohue	DEQE/DWS
Tara Gallagher	DEQE
Douglas Heath	EPA/OGWP
Kimberly Noake	DEQE
Michael Rapacz	DEQE/DWPC
Chi-Ho Sham	Boston Univ.

Data Group Additions for GIS Project

Gile Beye	DEQE/DWS
Deborah Cohen	EPA/IMB
Elizabeth Flynn	USGS
Michael Kanohi	EPA/IMB
Julio Olimpio	USGS

APPENDIX B

SUMMARY OF CCAMP AQUIFER ASSESSMENT COMMITTEE RECOMMENDATIONS

SEPTEMBER 24, 1986

I. RECOMMENDATIONS RELATING TO METHODS OF DATA REDUCTION

(Excerpted from: "Hydrogeological Considerations of Zone of Contribution Methods Used by Cape Cod Planning and Economic Development Commission and SEA Consultants, Inc. for Public Supply Wells in Barnstable, Massachusetts", see Appendix E)

II. RECOMMENDATIONS RELATING TO THE DELINEATION OF ZONE IIs

(Excerpted from the Aquifer Assessment Committee's report, "Evaluating Approaches to Determine Recharge Areas for Public Supply Wells", see Appendix F)

III. RECOMMENDATIONS RELATING TO DEQE'S TECHNICAL CAPABILITIES

IV. RECOMMENDATIONS RELATING TO ZONE OF TRANSITION MONITORING

I. RECOMMENDATIONS RELATING TO METHODS OF DATA REDUCTION

1. Municipal planners should make a comprehensive review of all existing information regarding the occurrence, movement and quality of groundwater in town (and adjacent areas of neighboring towns). Such a review will guide the subsequent collection of new data to protect public water supplies. To assist in this review process, the following table, using the town of Barnstable as an example, summarizes governmental sources and types of information available to town planners. Additional information may be available from geotechnical engineering companies which have performed work in Barnstable under a contractual basis. (CCPEDC)*

* Agency name in parentheses following each recommendation indicates agency responsible for implementation of the recommendation.

Level	Source Number	Government Agency or Firm	Location
Federal	1.	U.S. Geological Survey	Boston
	2.	U.S. Environmental Protection Agency	Boston
State	3.	Mass. DEQE - Main Office	Boston
	4.	Mass. DEQE - S.E. Regional Office	Lakeville
	5.	Mass. Water Resources Commission	Boston
County	6.	Cape Cod Planning and Economic Dev. Comm.	Barnstable
	7.	Barnstable County Health and Env. Dept.	Barnstable
	8.	Barnstable Board of Health	Hyannis
Town	9.	Barnstable Dept. of Public Works	Hyannis
	10.	Barnstable Fire District	Hyannis
	11.	Centerville-Osterville Fire District	Osterville
	12.	Cotuit Fire District	Cotuit
Private	13.	Anderson-Nichols	Boston
	14.	Barnstable Water Company	Hyannis
	15.	Charles A. Maguire & Assoc.	Waltham
	16.	Coffin & Richardson, Inc.	Boston
	17.	Down Cape Engineering	E. Brewster
	18.	IEP, Inc.	Barnstable
	19.	Metcalf & Eddy Inc.	Wakefield
	20.	Schofield Brothers, Inc.	Framingham
	21.	SEA Consultants, Inc.	Cambridge
	22.	Whitman & Howard, Inc.	Wellesley

Types and Source(s) of Information

a. Daily records of public-supply well discharge over the last five years (or existing records for wells less than 5 years old). Sources: 9,10,11,14

b. Aquifer pump-test data of test wells and water-supply wells.
Sources: 1,3,4,6,9,11,12,13,14,22

c. Public-supply and private well construction data
Sources: 1,3,4,5,6,7,8,9,10,11,12,14

d. Surface and groundwater evaluation data.
Sources: 1,6,9,10,11,12,13,14

e. Observations of temperature and precipitation data at Hyannis, Mass.
Sources: 9

f. Location and nature of sources of pollution in Barnstable.
Sources: all

g. Location and density of septic and sewage outflow.
Sources: 6,7,8,9

h. Water-quality data
Sources: 1,2,3,4,5,67,8,9

2. Aquifer pump-test data should be analyzed to determine the aquifer's transmissivity and storage coefficient, the specific capacity of the well and the depth and radius of the pumping well's cone of depression. This information may be obtained by applying one of the following analytical methods. Procedures outlined by these references will give satisfactory results depending on the completeness of the test data:

a. "A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History", by H.F. Cooper, Jr., and C.E. Jacob, 1946, Transactions of the American Geophysical Union, Vol. 27, no. 526-534, Washington, D.C.

b. "Analysis of Pumping Test Data From Anisotropic Unconfined Aquifers Considering Delayed Gravity Response," by S.P. Neuman, 1975, Water Resources Research, Vol. II, No. 2, pp. 329-342, Washington D.C.

c. "A Computerized Technique for Estimating the Hydraulic Conductivity of Aquifers from Specific Capacity Data", by K.R. Bradbury and E.R. Rothchild, 1985, Groundwater, Vol. 23, No. 2., pp. 240-254, Worthington, Ohio.

d. "Aquifer-Test Design, Observation and Data Analysis", by R.W. Stallman, 1971, Techniques of Water-Resources Investigations of the United States Geological Survey, Chapter B1, Book 3, Washington, D.C.

e. "Ground-Water Hydraulics", by S.W. Lohman, 1979, Geological Survey Professional Paper 708, Washington, D.C.

3. Water-evelation maps should be drawn from data obtained at both observation and non-pumping, supply wells. Maps constructed from data taken at least every three months will reflect the seasonal fluctuations in water-table elevations, flow directions and hydraulic gradients which affect the geometry and orientation of a pumping well's zone of contribution. In areas which have very gradual hydraulic gradients, hydrogeological conditions may require that elevation contours be drawn at one-foot intervals to accurately reflect local groundwater flow patterns in the vicinity of and upgradient of public-supply wells. (USGS, CCPEDC, DEQE)

II. RECOMMENDATIONS RELATING TO THE DELINEATION OF ZONE IIs

1. A demonstration of three-dimensional groundwater modeling is recommended. Ideally, the demonstration would include conditions where the advantages and disadvantages of the modeling approach could be defined and compared with those of the analytical approaches. Opportunities for model verification with past and future water-level data should be utilized. The models should be applied to areas with complex boundary conditions, multiple aquifer systems, multiple withdrawal points, and areally variable recharge, variable aquifer thickness, partial penetration, and changes in aquifer storage. Additional analyses could include comparison of the area of influence with area (zone) of contribution and determination of the upgradient boundary of the zone of contribution. The subject of data acquisition in terms of requirements and costs should be described. This will allow the determination of the benefits of a more realistic model (more accurate Zone II delineation) relative to the expense of collecting the data necessary to adequately define such a model. Action item - financing is needed for a modeling effort of this nature. (USGS, DEM/Division of Water Resources, DEQE, CCPEDC)

2. It is recommended that an evaluation of the existing hydrogeological data base take place in the pilot area. No action--EPA's Office of Ground Water Protection generated an interim report entitled "Hydrogeological Considerations of Zone of Contribution Methods Used by Cape Cod Planning and Economic Development Commission and SEA Consultants, Inc. for Public Supply Wells in Barnstable, Massachusetts." (EPA)

3. It is recommended that recharge data developed from Thornthwaite calculations be utilized in future delineations for Cape Cod. Sources of this data are Strahler, Palmer, Guswa and LeBlanc. No action -- data available. (DEQE -- guidelines for Zone II delineation, CCPEDC, USGS)

4. It is recommended that transmissivity data be developed from well pumping test data as outlined in the DEQE Guidelines for Public Supply Wells. Action item - Guidelines are currently being updated. (DEQE)

5. It is recommended that withdrawal data be based on a standard recommended percentage of the well capacity as determined in accordance with the DEQE Guidelines for Public Supply Wells. Action item - DEQE/DWS to provide Guidelines for percentage.(DEQE)

6. It is recommended that criteria for initializing water-level conditions be developed and the program for data acquisition be upgraded. Action item - Local, state and federal governments have the responsibility to design, create, and monitor an observation will network and publish water-level data. The Aquifer Assessment Group has accepted responsibility for providing detailed guidance for this action. (CCAMP AQUIFER ASSESSMENT GROUP, USGS, EPA, DEQE, DEM's Division of Water Resources, and CCPEDC)

III.RECOMMENDATIONS RELATING TO DEQE'S TECHNICAL CAPABILITIES

1. DEQE should develop a formal process to set and review the Department's technical objectives and to establish priority projects for funding. This process should involve one or more technical representatives from each DEQE division.

2. DEQE should develop and maintain a technical library. (DEQE)

IV. RECOMMENDATIONS RELATING TO ZONE OF TRANSITION MONITORING

1. USGS has installed monitoring wells of various depths around the shoreline to observe the salt water/fresh water interface. With CCPEDC, they monitor these wells twice a year for specific conductance, sodium and chloride. No major trends have been observed except in one well in Truro. This well's salinity levels have been decreasing because of the cessation of pumping from the South Hollow Wellfield. Auction item -- BCHED will monitor the Truro well monthly with equipment provided by USGS. CCPEDC should monitor the other wells once yearly. (CCPEDC).

APPENDIX C

WATER-TABLE ELEVATIONS IN EASTERN BARNSTABLE, MASSACHUSETTS

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U. S. Environmental Protection Agency, Region 1
Boston, MA

July 1987

Introduction and Purpose

The town of Barnstable is fortunate to have a good supply of ground water for its public-water supply, industrial, commercial, recreational and agricultural needs. As the town continues to develop, more demands will be made for this resource. To help town planners understand the groundwater system and to protect it from a variety of pollution sources, the Cape Cod Aquifer Management Project (CCAMP) produced a map showing the shape and elevation of the water table. The mapped area is in the eastern half of the town and in part of western Yarmouth, a region of Cape Cod which has experienced high growth over the last thirty years.

The purpose of mapping the water table is to display the occurrence and movement of groundwater as it moves under the force of gravity from high to low elevations. The map produced by CCAMP indicates the position of the water table undisturbed by pumping stresses from public supply wells. The extent of ground water contamination from underground storage tanks, chemical spills, road salt and septic system effluent, and other sources, and the directional velocity of contaminated plumes, can be better understood from the configuration of the water table. Another important purpose is to help define areas of recharge to pumping wells which must be protected from contamination to safeguard public health.

Previous investigators have produced local and regional maps of the water table.In 1977, the U.S. Geological Survey (USGS) published a Cape wide water-table map based on observation well and pond data obtained in May, 1976. The map identified six major fresh water lenses which supply potable water to residents of Cape Cod (LeBlanc and Guswa, 1977). Information from this study helped to provide a basis for estimating high ground water levels (Frimpter, 1980) and to refine and calibrate a USGS three dimensional numerical model of Cape Cod's ground water system (Guswa and LeBlanc, 1981). In 1982, the Cape Cod Planning and Economic Development Commission used the water-table map to delineate zones of contribution to public supply wells (Horsley, 1983). In 1984, SEA Consultants, Inc. obtained water-table elevations at 17 observation wells to produce computer simulations of piezometric head. These maps indicated the response of the water table in Barnstable to various amounts of recharge and wastewater, especially at the Barnstable Waste Water Treatment Facility (WWTF). The maps also provided information to delineate zones of contribution to public supply wells in Barnstable (SEA Consultants, Inc., 1985). However, the study did not define the flow patterns of ground-water in the vicinity of surface water bodies or the coastline, which affect local hydraulic gradients and flow directions. Recently, water table-maps for smaller areas of the town have been made that show groundwater directions related to suspected sources of contamination. Some of these studies were done in compliance with MGL Chapter 21E and in response to requests by the town of

Barnstable at the Barnstable County Fire Training Facility and the WWTF (GHR, 1986; IEP, Inc., 1986; Whitman and Howard, Inc., 1987).

Acknowledgments

The Cape Cod Aquifer Management Project wishes to thank the following individuals and organizations for their assistance and cooperation in this project: Daniel Leahy, Barnstable Department of Planning and Development; David Green and Arthur Marney of the Barnstable Department of Public Works; Michael Kruse, Town of Yarmouth; Gabrielle Belfit and David Janik, Cape Cod Planning and Economic Development Commission; Peter Doyle, Barnstable Waste Water Facility; Normand Nault, Barnstable Water Company; George Weir, Barnstable Fire District; Donald Rugg, Centerville-Osterville Fire District; Paul Wilson and Rick Crowley, Yarmouth Water Company; Thomas Cambareri, IEP, Inc.; Steven Wood, Commonwealth Electric Company; Kevin Hehir, Barnstable Airport; Al Comeau, Cummaquid Golf Course; Tara Gallagher, DEQE; and Lee Steppacher and Karen Wilson, EPA. It also wishes to thank Michael Frimpter for providing information and well data on file at the U.S. Geological Survey in Boston, Massachusetts, and Alison C. Simcox for her helpful editorial assistance.

Procedure

Locations and data of observation wells in Barnstable and Yarmouth were obtained from twelve public and private organizations during the six-month investigative phase of the project (Summer - Fall, 1986). Of the initial 215 wells identified for potential inclusion for the study, 71 (about one-third) were eventually selected for use. The final choice was based on the availability of information including location, ownership, access, construction data, drillers' logs, survey records, and a field check before actual readings were taken to ensure that the selected wells were not lost or damaged. In addition, individual wells were selected within clusters to provide representative data in the area. In total, the elevations of the water table was measured at 71 wells and 7 ponds (see table).

The most accurate method of water-table measurement at a well is made by determining the vertical distance from a known elevation such as the top of a well casing to the water level inside of the well. In this study, measuring-point elevations were provided by cooperating agencies and measuring tapes graduated in hundredths of a foot were used. While nearly all of the 71 wells had surveyed elevations, three (Nos. 47, 48, and 71 in table) did not. Estimates of elevations for these wells were made from the USGS 7.5 minute Hyannis quadrangle (USGS, 1979) and were assumed to be accurate within five feet, versus 0.01 feet for other points.

The elevations of seven ponds in the study area were obtained on May 13, 1987 by using local benchmarks and standard levelling techniques. To mitigate the effects of waves, temporary stilling wells consisting of perforated PVC casing were driven into shallow pond sediments within three

feet of the shore. Depths to water were subtracted from well elevations to obtain the elevation of the pond surface. Because of its large size, Wequaquet Lake was surveyed at two locations: in the northwest near a public landing on Shootflying Hill Road and in the south at the herring run at Phinney's Lane and Melody Pond. On May 13, 1987, the observed elevations of the lake surface at these locations were 34.45 and 34.44 feet above sea level, respectively.

A map of water-table elevations was superimposed on the 7.5 minute Hyannis quadrangle. Contours of equal elevations were drawn at five foot intervals from 10 to 35 feet and one foot intervals from 35 to 38 feet. Contours were dashed where approximate. In producing the contours, the location, size and shape of surface-water bodies, including ponds, rivers, wetlands and tidal estuaries, were considered. For example, kettle hole ponds, which were originally sites of large blocks of melting glacial ice in outwash sediments, are surface expressions of the water table. Because of their essentially level surfaces, contours were drawn around the shorelines of these and other surface-water bodies.

Discussion

Elevation of ground water in eastern Barnstable and western Yarmouth ranged from sea level along Cape Cod Bay and Nantucket Sound to 38.82 feet at observation well W-7 (No. 27), approximately 0.5 mile northwest of the waste water treatment facility. Wells located along the shoreline are subject to tidal effects which range from 3.1 feet in Nantucket Sound to 9.5 feet in Cape Cod Bay (USGS, 1979).

Because of high precipitation during the winter and spring of 1987, the water table rose to record levels in May at several locations in the study area. A1W 230 (No. 62), which has been used since 1958 as an observation well, had a record high water-table elevation of 21.99 feet on May 20th. Observation wells A1W 247 (No. 63) and YAW 85 (No. 61) were also at record levels. Past measurements indicate that water-table elevations at these locations can fluctuate from 5 to nearly 8.5 feet over their periods of record.

Barnstable has 31 public-supply wells which provide potable water to its residents. Seventeen of these wells and three in Yarmouth are located in the study area. Pumping wells create cones of depression in the water table around their well casings. In eastern Barnstable they may range in size from about 250 to 2900 feet in diameter. The size and magnitude of these drawdown cones change in response to pumping rate and duration and can perturb ground water gradients. To help mitigate the effects of well pumping, the water table was measured before the onset of the summer months of peak demand. Only three wells were known to be operating during the observation period: Mary Dunn No. 2, Simmons Pond and Airport No.1. During the period of field measurement, only observation wells located outside of these wells' areas of influence were used.

The configuration of the water table in eastern Barnstable has several

important features. The first is a large "mound" of ground water east of Wequaquet Lake. During the May, 1987 observation period, its elevation was over four feet higher than this large surface water body. The mound's elevation and shape indicate that water flows radially outward near the intersection of Pitchers Way and Bearses Way. In the area between the center of the mound and Wequaquet Lake, the direction of ground-water flow is to the west, while regional flow directions in this part of Cape Cod are generally eastward. Another noteworthy feature shown by the water table map is the effect of Wequaquet Lake on local ground water flow directions. With an area of over one square mile, Wequaquet Lake is the largest surface water body on Cape Cod. The water lost by evaporation and the herring run outlet on its southern shore is replaced by ground water discharging to the pond along its western, northern and eastern shores. In addition, lake water recharges the aquifer along its southern shore and moves in the direction of Nantucket Sound.

The relationship between Wequaquet Lake and the mound of ground water has important implications for water management strategies and the delineation of wellhead protection areas in this portion of Barnstable. As the elevation of the water table fluctuates in response to aquifer storage, the gradient (or slope) of the water table between the lake and the mound's center may also change. As the amount of ground water in storage in the aquifer decreases, the elevation of the water table and of the mound will decrease as well. The water-table gradient towards the lake will be less pronounced and less discharge into the lake from the area of the mound will occur. Because season and climate affect the direction and velocity of ground-water flow, they must be considered when delineating recharge zones near pumping wells and when determining contaminant flow direction and velocity.

All but one of the 71 wells used as observation points are screened in the shallow sand and gravel aquifer underlying the mapped area. They range in depth from 6 to 102 feet. Beneath this permeable layer of varying thickness are extensive clay strata which locally are quite thick. For example, Well A1W 318 (No. 68) in northern Barnstable is screened in 77 feet of clay to a depth of 87 feet. Because the clay confines the aquifer in this area, ground water is artesian and tends to flow from wells onto the land surface. In the Hyannis area, well C-4 (No. 22) penetrated 15 feet of "blue clay" and gray sandy silt from 50 to 65 feet below the land surface (Maravell and others, 1983).

Precision and Accuracy

Every attempt was made to reduce potential sources of error. Mistakes may occur in measuring or recording the depth to water at a well due to water condensation or pressure variations within the well casing. If a depth measurement was uncertain at the first attempt, the field observer made additional measurements until the true depth to water was confirmed. In all cases, the precision of measurement sought was .01 feet. Errors may

also occur in surveying the tops of well casing. Elevation data for observation wells were obtained from existing files and engineering reports. It was not possible to verify their accuracy. And errors also may result from incorrect positioning of wells and water-table contours on a base map. All well locations were checked in the field either before or during well measurement. Contours were hand drawn using standard techniques of interpolation. They are dashed where there is insufficient information to locate them precisely.

Summary and Conclusions

Sufficient information exists to map the water-table aquifer in eastern Barnstable and western Yarmouth to assist town planners in evaluating and protecting valuable ground water resources. It is important that both regional and local ground water flow patterns be understood and described, particularly with respect to surface water bodies.

The distribution of water-table elevations obtained during this study does not reflect average conditions. Heavy precipitation during the winter and spring months of 1987 recharged the aquifer in excess of average amounts, and water-table elevations at several locations were at record high levels for their periods of measurement. Average ground-water elevations are typically two to three feet lower than those shown on the map and the accompanying table.

The complex relationship between Wequaquet Lake and the surrounding aquifer should be investigated more fully. Surface and water-table elevations in the vicinity of the lake should be measured seasonally as they may respond differently to variations in aquifer storage. If the range of seasonal fluctuation is greater in the water-table mound than for Wequaquet Lake, then potential changes in groundwater velocity and direction may occur in this area.

The gathering and compilation of the various pieces of information regarding possible observation well locations and related data proved to be a time consuming process. As noted, sufficient wells and information existed to support a detailed water-table elevation project in Barnstable. However, a comprehensive program to collect and maintain the data in a central location is lacking. We suggest that towns, governmental agencies and private research firms investigate the establishment of an interagency data base for observation well data, including well number (and cross reference), location (map, coordinates, etc.), elevation, logs and owner. The use of a Geographic Information System (GIS) and existing data bases such as STORET (EPA) and GWSI (USGS) should be explored. It is hoped that the establishment of such a system would assist the towns in their ground water protection programs and avoid repetitive and costly research in the future.

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Table of Water-Table Elevations, CCAMP 5/11-13/87

TABLE OF OBSERVATION WELLS AND WATER-TABLE ELEVATIONS

No.	Well Name	Date Measured	Well Depth	MP Elev.	Depth to Water Below MP	Water-table Elevation
1.	BFD #1 57-A (AIW-295)	5/11/87	49	38.61	8.73	29.88
2.	BFC #1 52-2B (AIW-290)	5/11/87	56.2	48.29	16.83	31.46
3.	BFD #1 76-16 (52-2C)	5/11/87	---	52.80	20.44	32.36
4.	BFD #2 84-4	5/11/87	24*	45.31	9.50	35.81
5.	BFD #2 86-1	5/11/87	17*	37.00	3.10	33.90
6.	BFD #2 64-K-A	5/11/87	67.9*	43.14	9.65	33.49
7.	BFD #2 84-3	5/11/87	24*	44.91	9.40	35.51
8.	BFD #2 64-E	5/11/87	63.3*	40.28	5.23	35.05
9.	BFD #3 64-D (AIW-293)	5/11/87	63	39.49	2.40	37.09
10.	BFD #3 84-1	5/11/87	---	61.80	24.39	37.41
11.	BFD #3 77-1	5/11/87	49	53.43	19.37	34.06
12.	Barnstable Airport MW-1	5/11/87	---	54.06	20.51	33.55
13.	Barnstable Airport MW-3	5/11/87	---	52.58	21.19	31.39
14.	Barnstable Airport OW-1	5/11/87	40	55.79	21.36	34.43
15.	Barnstable Airport OW-5	5/11/87	35	49.68	17.25	32.43
16.	BSTP BA-3	5/11/87	26	47.03	14.24	32.79
17.	BSTP BB-3	5/11/87	25	32.19	12.22	19.97
18.	BSTP BC-1	5/11/87	66	44.63	7.35	37.28
19.	BSTP BE-1	5/11/87	50	50.23	26.53	23.70
20.	BSTP C-1	5/11/87	77	40.83	12.77	28.06
21.	BSTP C-2	5/11/87	42	43.34	8.64	34.70
22.	BSTP C-4	5/11/87	57	40.03	17.22	22.81
23.	BSTP C-5	5/11/87	45	21.89	5.73	16.16
24.	BSTP W-1	5/11/87	27	49.75	14.71	35.04
25.	BSTP W-4	5/11/87	20	36.17	8.16	28.01
26.	BSTP W-5	5/11/87	26	40.43	16.57	23.86
27.	BSTP W-7	5/11/87	41	64.88	26.06	38.82
28.	BSTP W-8	5/11/87	43	62.86	26.71	36.15
29.	BSTP W-9	5/11/87	45	67.37	29.82	37.55
30.	Tom Cambareri TC-1	5/11/87	6	37.58	0.30	37.28
31.	Tom Cambareri TC-2	5/11/87	---	38.73	4.14	34.61
32.	S-1	5/11/87	58	54.53	18.85	35.68
33.	S-2	5/11/87	58	57.86	21.60	36.26
34.	S-3	5/11/87	71	73.27	36.61	36.66
35.	S-4	5/11/87	76	67.44	30.07	37.37

NOTE: All depths and elevations are in feet.

MP = measuring point (top of well casing or PVC, whichever is higher).
* = well depth below measuring point; all others are depths below land surface.
T = denotes water level affected by local tides.
E = denotes elevations estimated from topographical contours on the USGS 7.5-minute Hyannis, Massachusetts quadrangle, photo-revised in 1979. Values are assumed to be within + 5 feet of actual elevations.
USGS = U. S. Geological Survey Observation Well
BFD = Barnstable Fire District
BSTP = Barnstable Sewage Treatment Plant
BWC = Barnstable Water Company
C/O = Centerville-Osterville Fire District
BFTF = Barnstable Fire Training Facility
YWC = Yarmouth Water Company

Table of Water-Table Elevations, CCAMP 5/11-13/87

TABLE OF OBSERVATION WELLS AND WATER-TABLE ELEVATIONS

No.	Well Name	Date Measured	Well Depth	MP Elev.	Depth to Water Below MP	Water-table Elevation
36.	S-6	5/11/87	65	50.34	20.18	30.16
37.	S-7	5/11/87	75	61.75	26.88	34.87
38.	S-8	5/11/87	75	31.45	3.25	28.20
39.	S-9	5/11/87	102	55.08	35.42	19.66
40.	S-11	5/11/87	63	60.11	21.46	38.65
41.	S-12	5/11/87	70	71.23	32.73	38.50
42.	S-14	5/11/87	55	55.83	22.70	33.13
43.	S-15	5/11/87	63	49.05	19.46	29.59
44.	S-16	5/11/87	59	41.99	17.96	24.03
45.	S-17	5/11/87	60	59.84	24.30	35.54
46.	S-18	5/11/87	70	55.08	17.11	37.97
47.	BWC AIW 299	5/12/87	56	33E	2.71	30.29E
48.	BWC Maher Diesel 1 Obs. Well	5/12/87	---	15E	4.18	10.82E
49.	BWC Straightway Obs. ST-1	5/12/87	57	20.70	3.80	16.90
50.	BWC Test Well 1, 150' North of School House Road	5/12/87	98.5*	31.54	19.86	11.68
51.	BWC Test Well 2, 130' South of School House Road	5/12/87	---	25.17	14.56	10.61
52.	C/O Station #7	5/11/87	63	21.44	6.88	14.56
53.	C/O Station #8 Obs. 8-1	5/11/87	---	25.05	10.30	14.75
54.	C/O Station #11 Obs. 11-1	5/11/87	---	26.77	11.62	15.15
55.	Cummaquid Golf Course GC-C2	5/11/87	54	33.72	9.21	24.51
56.	Cummaquid Golf Course GC-C3	5/11/87	129	45.07	23.86	21.21
57.	Hyannisport GC AIW-322	5/11/87	97	8.20	2.76	5.44T
58.	Commonwealth Electric OW-6S	5/11/87	14.5	39.34	9.49	29.85
59.	BFTF IEP OW-2	5/11/87	24	38.13	5.82	32.31
60.	BFTF IEP MW-16S	5/11/87	35	54.45	23.42	31.03
61.	USGS YAW-85	5/11/87	59.9	35.03	8.59	26.44
62.	USGS AIW-230	5/11/87	35.85	42.50	20.53	21.97
63.	USGS AIW-247	5/11/87	52	46.50	22.88	23.62
64.	USGS AIW-254	5/11/87	40	47.45	7.72	39.73
65.	USGS AIW-292	5/11/87	51	41.65	4.58	37.07
66.	USGS AIW-294	5/11/87	60	30.75	9.83	20.92
67.	USGS AIW-306	5/11/87	31	53.60	21.27	32.33
68.	USGS AIW-318	5/11/87	87	12.16	1.23	10.93T
69.	YWC MW-7A (YAW-123)	5/11/87	34.2	18.92	8.94	9.98
70.	YWC 300-21 (73-84)	5/11/87	28.3	39.29	10.35	28.94
71.	YWC 22A-77	5/11/87	25	31E	11.04	19.96E

NOTE: All depths and elevations are in feet.
MP = measuring point (top of well casing or PVC, whichever is higher).
* = well depth below measuring point; all others are depths below land surface.
T = denotes water level affected by local tides.
E = denotes elevations estimated from topographical contours on the USGS 7.5-minute Hyannis, Massachusetts quadrangle, photo-revised in 1979. Values are assumed to be within + 5 feet of actual elevations.
USGS = U. S. Geological Survey Observation Well
BFD = Barnstable Fire District
BSTP = Barnstable Sewage Treatment Plant
BWC = Barnstable Water Company

Table of Water-Table Elevations, CCAMP 5/11-13/87

TABLE OF OBSERVATION WELLS AND WATER-TABLE ELEVATIONS

No. Ponds and Lakes	Date	Size in Acres	Town	Elevation
1. Wequaquet Lake	5/13/87	654	Barnstable	34.44
2. Melody Pond	5/13/87	3	Barnstable	34.44
3. Long Pond	5/13/87	50	Barnstable	27.05
4. Shallow Pond	5/13/87	67	Barnstable	36.05
5. Mary Dunn Pond	5/13/87	16	Barnstable	28.66
6. Simmons Pond	5/13/87	7	Barnstable	8.56
7. Dennis Pond	5/13/87	---	Yarmouth	25.9E

NOTE: All depths and elevations are in feet.
MP = measuring point (top of well casing or PVC, whichever is higher).
* = well depth below measuring point; all others are depths below land surface.
T = denotes water level affected by local tides.
E = denotes elevations estimated from topographical contours on the USGS 7.5-minute Hyannis, Massachusetts quadrangle, photo-revised in 1979. Values are assumed to be within + 5 feet of actual elevations.
USGS = U. S. Geological Survey Observation Well
BFD = Barnstable Fire District
BSTP = Barnstable Sewage Treatment Plant
BWC = Barnstable Water Company
C/O = Centerville-Osterville Fire District
BFTF = Barnstable Fire Training Facility
YWC = Yarmouth Water Company

APPENDIX D

DRASTIC MAPPING OF AQUIFER VULNERABILITY IN EASTERN BARNSTABLE AND WESTERN YARMOUTH, CAPE COD, MASSACHUSETTS

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The permeable glacial deposits of Cape Cod are highly vulnerable to contamination from improper storage, handling and spillage of hazardous chemicals. The towns of Barnstable and Yarmouth -- like all communities on the Cape -- rely on ground water to supply the needs of their citizens. The risk of contamination of ground water resources will increase unless preventive measures are taken.

In 1986, the Cape Cod Aquifer Management Program began a study of land uses within Zone I, an area of recharge to nine public supply wells in eastern Barnstable, which has experienced rapid development over the last thirty years. With an area of 3,650 acres, Zone I is the largest zone of contribution in Barnstable. The study included a detailed inventory of common land uses, such as an airport and industrial park, service stations, dry cleaners and septic systems that might contain sources of pollution that threaten the quality of ground water (Gallagher and Steppacher, 1987; SEA Consultants, 1985). The study also included an analysis of the relative vulnerability of soils and ground water to chemicals generated by such activities. Using the methods and criteria in DRASTIC (Aller and others, 1985), the pollution potential for contamination in Zone I was evaluated, mapped and incorporated into a geographical information system developed by the U. S. Geological Survey. The purpose of this paper is to describe how DRASTIC was applied as a mapping tool for ground-water management in this hydrogeological setting.

DRASTIC

As a standardized system developed jointly by the U.S. Environmental Protection Agency and the national Water Well Association, DRASTIC is designed to provide numerical rating of relative vulnerability to contamination in most hydrogeological settings found in the United States. The name is an acronym for seven factors that influence how quickly chemicals may move through unsaturated and saturated soils and rock. These are Depth to water, net Recharge, Aquifer media, Soil media, general Topography, Impact of the vadose zone and the hydraulic Conductivity of the aquifer. These seven factors are assigned numerical weights and ratings that, when added together, provide a vulnerability in a wide variety of settings, DRASTIC is not designed for use in areas small than 100 acres.

In eastern Barnstable and western Yarmouth, Zone I consists of two hydrogeologic settings. Two thirds of the area is made up of Barnstable Outwash Plain deposits of permeable sand and fine gravel with beds of silt and clay. The relief of the land surface is moderate, ranging in elevation from sea level to about 40 feet. Ground water is generally less than 50 feet deep. All nine public supply wells are screened in the outwash

plain portion of Zone I. The northern third of the study area consists of Sandwich Moraine deposits of silt, sand and gravel (Oldale, 1974). Elevations range from 40 to 150 feet above sea level and depths to ground water vary from zero to over 125 feet. Because of changes in aquifer storage caused by variations in recharge, evapo-transpiration and pumping, the elevation of the water table in Zone I may fluctuate as much as eight feet.

Procedure

The successful application of DRASTIC is based on the availability of accurate information about the hydrogeology, topography and climate of an area. For Zone I, information was gathered from local water table, topographic and geologic maps, driller's logs, aquifer test data and climatological records.

The table following this report shows the factors, ranges, ratings and weights used to calculate total DRASTIC numbers at locations in the outwash and moraine settings. Individual factor numbers in the right hand column for each setting were held constant except for depth to water, which varied widely over the area (see Heath and Mascoop, 1987, this volume). Depth to water information was obtained by superimposing contours of water-table and topographic elevations and calculating their difference in feet. Depths to water observed in wells were also used. These methods produced 648 data points within Zone I for which DRASTIC numbers could be derived. The final step of contouring these point values resulted in the DRASTIC map shown in the accompanying figure. Higher values denote areas of increased vulnerability to contamination.

Results

In a national context, the values of relative vulnerability derived by the DRASTIC system may range from a low of 23 for a dry, mountainous setting of shale or clay to a high of 226 for a humid, karst-limestone environment. The derived values of 140 to 185 for the Sandwich Moraine setting and 185 to 210 for the Barnstable Outwash Plain setting in Zone I indicate moderate to high vulnerability to contamination. Other areas of Cape Cod that have similar hydrogeologic and climatic conditions are also likely to share these values. The results of this study show that low-lying areas and areas next to surface water bodies are most at risk where the depth to water is less than three feet. The areas that are relatively least vulnerable, with DRASTIC scores of 140 to 159, are the highest portions of the Sandwich Moraine along State Route 6.

The DRASTIC system of assessing soil and aquifer vulnerability requires knowledge regarding seven factors which affect contaminant mobility. In this application at a 5.7 square mile area in Barnstable and Yarmouth, the factor having the most information to support it was general topography,

followed (in descending order) by depth to water, soil media, aquifer media, net recharge, impact of the vadose zone and hydraulic conductivity. DRASTIC was most successfully applied in the Barnstable Outwash Plain region of the study area because of the availability of extensive well information. In contrast, no well information was available for the Sandwich Moraine portion of Zone I and the ranges for all DRASTIC factors except for net recharge, soil media and topography had to be estimated from areas of the moraine outside of Zone I.

Acknowledgments

I am grateful to Kim Franz of the U.S. Environmental Protection Agency and Beth Flynn of the U.S. Geological Survey for their assistance in producing the DRASTIC map of Zone I.

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TABLE OF RANGES, RATING AND WEIGHTS FOR DRASTIC STUDY

OF

ZONE I, CAPE COD, MASSACHUSETTS

Barnstable Outwash Plain Setting

Factor	Range	References*	Rating	Weight	Number
Depth to Water	0-50+ feet	4,8	5-10	5	25-50
Net Recharge Per Year	10+ inches	6	9	4	36
Aquifer Media	Sand & Gravel	4,6	9	3	27
Soil Media	Sand	4	9	2	18
Topography	2-6%	8	9	1	9
Impact of Vadose Zone	Sand & Gravel	6	8	5	40
Hydraulic Conductivity	2000 + gpd/ft^2	3,6	10	3	30

Total = 185-210

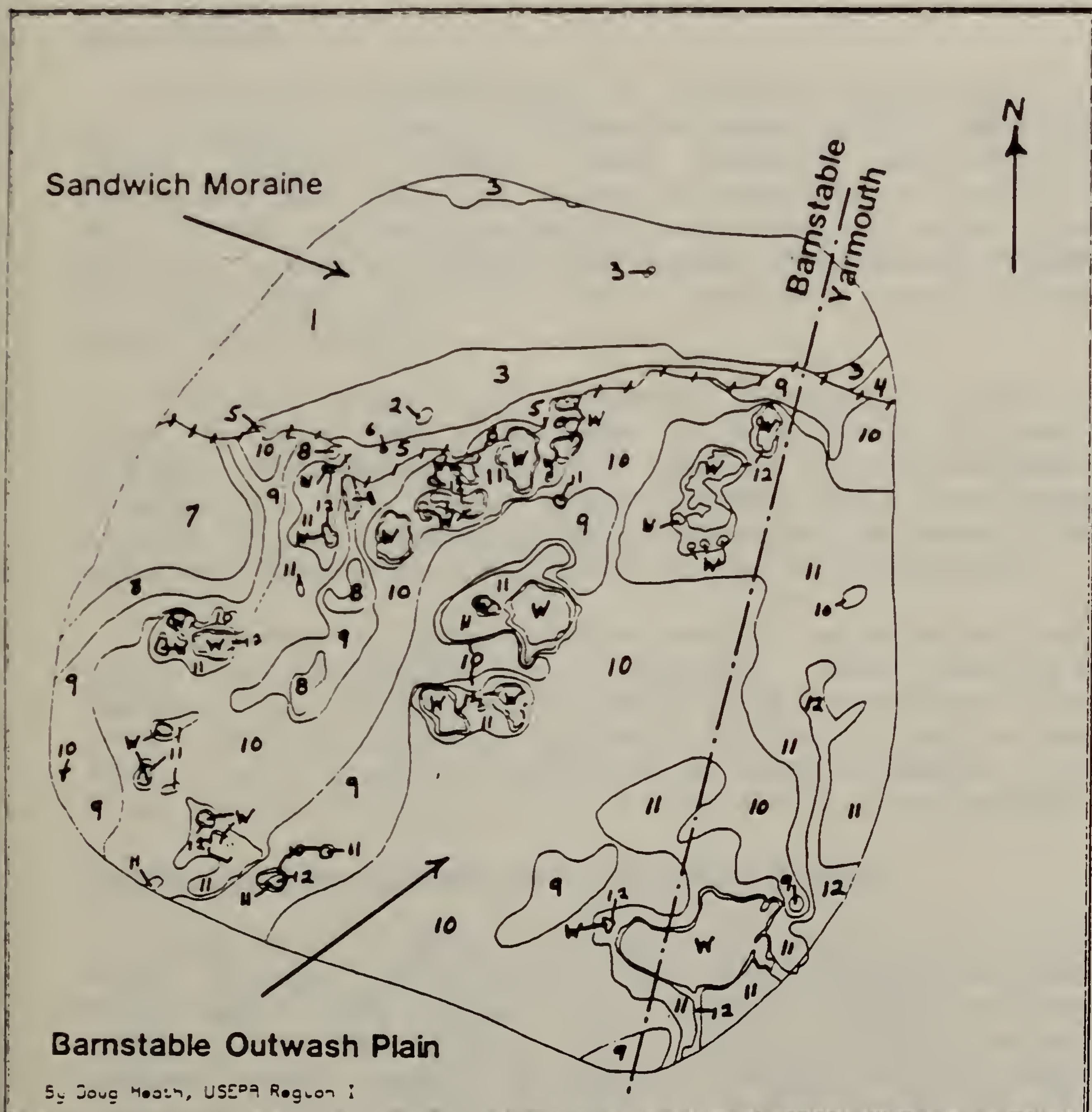
Sandwich Moraine Setting

Factor	Range	References*	Rating	Weight	Number
Depth to Water	0-100+ feet	4,8	1-10	5	5-50
Net Recharge Per Year	10+ inches	6	9	4	36
Aquifer Media	Sand & Gravel	1,4,6	8	3	24
Soil Media	Sandy Loam	1	6	2	12
Topography	6-12%	8	5	1	5
Impact of Vadose Zone	Sand & Gravel	1,6	8	5	40
Hydraulic Conductivity	700-1000gpd/ ft^2	3,6	10	3	30

Total = 140-185

Note: gpd/ft^2 = gallons per day per square foot
* Refer to list of references at the end of this report.

DRASTIC CONTOURS FOR ZONE I, BARNSTABLE-YARMOUTH, MASSACHUSETTS



EXPLANATION

DRASTIC VALUES

1: 140-159
2: 155-159
3: 160-169
4: 170-174
5: 170-179
6: 180-184
7: 185-189
8: 190-194
9: 195-199
10: 200-204
11: 205-209
12: 210

W: Water

Moraine/Outwash Contact

APPENDIX E

HYDROGEOLOGIC CONSIDERATIONS OF ZONE OF CONTRIBUTION METHODS USED BY CAPE COD PLANNING AND ECONOMIC DEVELOPMENT COMMISSION AND SEA CONSULTANTS, INC. FOR PUBLIC-SUPPLY WELLS IN BARNSTABLE, MASSACHUSETTS

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December, 1985

Introduction

Successful determination of a public-supply well's zone of contribution requires accurate information about the following factors: well discharge, aquifer recharge, local hydraulic gradient of the water table, horizontal and vertical hydraulic conductivity, and the saturated thickness of the aquifer from which a well draws its water. Additional factors such as a well's proximity to sources of pollution, fresh/salt-water bodies and urban areas are also important considerations in protecting ground-water quality.

Previous attempts to determine protection areas for public-supply wells on Cape Cod were made in 1982-1983 by the Cape Cod Planning and Economic Development Commission (CCPEDC) and for Barnstable in 1985 by SEA Consultants, Inc. (SEA). Both attempts combined analytical and numerical methods which differed in both assumptions and data, resulting in limited agreement about a particular zone's size or orientation.

Refinement of these methods consists in tailoring each zone of contribution to individual site conditions, which entails understanding the natural flow system and assessing basic assumptions. The purpose of this paper is to describe the necessary factors, to outline sources of information, and to provide a comparison of recent attempts to delineate recharge areas for public-supply wells in Barnstable, Massachusetts.

Barnstable Public-Supply Well Discharge Records

Barnstable township is currently served by 31 public water supply wells operated by three municipal fire districts and one private company. These wells have pumps which operate independently from one another in response to distribution head changes in their respective water-supply systems which connect the source of supply to both commercial and private residents. Each supplier maintains records of daily well pumpage at individual wells measured in gallons per day. According to company superintendents, historical accounts of daily discharge extend back at least to 1975 at both the Barnstable Water Company and the Centerville-Osterville Fire District, to 1972 at the Barnstable Fire District, and at least to 1950 at the Cotuit Fire District. Pumping records indicate that because of seasonal fluctuations in demand, a public-supply well may operate for 24 hours a day over many weeks during the summer, yet remain idle for several months during the winter. In addition, wells are occasionally taken off-line" for pump maintenance, screen cleaning or the installation of

improved telemetering systems.

Reports of water-department statistics are submitted annually by public water-supply companies to the Massachusetts Department of Environmental Quality Engineering (DEQE). The following table summarizes the total volume of groundwater extracted, the length of each system and the number of services or individual hook-ups in Barnstable at the end of 1984:

Water Company	No. of Gallons Pumped	Well Sites	Miles of Mains	No. of Services
Barnstable Water Co.	1,016,042,000	11	45.32	6,358
Centerville-Osterville Fire District	693,735,000	13	210.00	8,500
Barnstable Fire District	137,907,000	3	41.03	1,378
Cotuit Fire District	103,761,800	4	44.98	1,412
Total	1,951,445,800	31	341.33	17,648

The highest annual well discharge in 1984 was 237,804,000 gallons at Mary Dunn #2, operated by the Barnstable Water Company. This well, located north of the Barnstable Municipal Airport, operated during every month of the year at a mean rate of 651,518 gallons per day (gpd) or 452.4 gallons per minute (gpm). The lowest well discharge in 1984 was 1,960,000 gallons at Barnstable Fire District's GP Well #1, located just west of Phinney's Lane and approximately 900 feet north of U.S. Highway 6. This well operated every month except during March at a mean rate of 5,370 gpd or 3.7 gpm.

Well Discharge and Safe Yield

The zone of contribution methods used by Cape Cod Planning and Economic Development Commission (1983) and SEA Consultants (1985) rely solely on the "rated safe yield" of a well for discharge information. The safe yield (SY) may be defined as the maximum rate of extraction that a well can safely pump without depleting an aquifer over a specified time interval. In accordance with General Laws Chapter 111, Section 17, the DEQE defined the safe yield of a public water well as:

SY = (T) x (available water) x (safety factor)

where SY = safe yield in gallons per day

T = aquifer transmissivity, in gallons per day per foot, determined by the modified non-equilibrium method of Cooper and Jacob (1946).

Available water = (depth of pumping well) - (screen length) - (static water level) - (5 feet)
Safety factor = 0.75

Safe yields determined by CCPEDC and SEA for the 31 public-supply wells in Barnstable are available from computation sheets (Table 1) and on Table 2 (SEA, Table 8.10, 1985), respectively. Information on safe yields used by SEA resulted from interviews with the water companies. The two sets of well capacity values differ considerably, and agree for only 7 wells, or 23 percent of public-supply wells in Barnstable (Table 3). According to CCPEDC, safe-yield capacities range from 290 gpm at Centerville Osterville's Craig #11 to 1000 gpm at Barnstable Water Company's Airport well. Values for safe yields published by SEA range from 275 gpm at Cotuit's Electric #3 to 1,400 gpm at Barnstable Water Company's MDL 1 and 2. The use of different sets of values for safe yield for over 75% of the wells makes it difficult to compare zones of contribution because variations in pumping capacities strongly influence the size of recharge areas.

Recognizing that Barnstable public-supply wells do not continuously pump at their full capacity, CCPEDC multiplied the safe yield by a general reduction factor to more closely approximate average well discharge. A value of 60 percent was used uniformly for all wells to simulate a steady-state condition over an extended period of time. In SEA's method, pumping of public-supply wells within zones 1, 2 and 8 were kept at their rated safe yields to simulate future average day demand. The discharges for wells in the remaining zones were simulated at 60% of their rated safe yield.

<u>Recharge</u>

Recharge may be defined as the volume of water which reaches the saturated zone of an aquifer where it is available for extraction. Several investigators have estimated recharge rates in inches per year for different areas of Cape Cod and Martha's Vineyard. Palmer (1977) studied aquifer recharge while conducting research at a wastewater experimental site at the Massachusetts Military Reservation, eight miles west of Barnstable township. He described the water balance at this site by the equation:

Recharge = P - ET - SR

where P = precipitation, ET = evapotranspiration from surface water bodies and vegetation and SR = surface runoff. Because of the high permeability of surficial deposits for most of Cape Cod, Palmer assumed that there is little or no runoff and the last component could be neglected. Therefore, the above equation reduces to:

Recharge = P - ET

Using mean monthly temperature and precipitation data for several climatological stations on Cape Cod, he estimated annual evapotranspiration levels from 1965 to 1975 using the Thornthwaite calculation, (Thornthwaite and Mather, 1957). The results of these calculations, which are presented

in Tables 4 and 5, indicate that average annual ET is relatively constant for any station over a number of years, varying less than 2 inches over the observation period. The least amount of ET was found at the Chatham station (24.7"), while the highest calculated ET was found at the Woods Hole station (25.93"). Based upon the small difference in calculated ET between widely-spaced stations on Cape Cod, Palmer concluded that the amount of precipitation is the principal factor affecting the amount of natural recharge at any one locality.

Palmer also calculated the potential evapotranspiration from the Long Pond pumping station in Falmouth from 1960 to 1976 (Table 6) and subtracted these values from observed precipitation collected at Hatchville to give estimated recharge values (Table 7). The data indicate a mean loss of recharge over June, July and August with the greatest deficit occurring in July (-2.29 inches). The highest recharge estimates occurred from November to March with the highest value in December (4.47 inches). Annual recharge during the drought year 1965 was nearly nil when ET nearly equaled precipitation in the Falmouth area. It reached a high level of nearly 48 inches in 1972, which had a relatively cool summer and wet autumn. While the data presented by Palmer are only estimates at one locality, they indicate that annual recharge can vary considerably from one year to the next.

Strahler (1972) also used the Thornthwaite method to determine monthly potential ET and groundwater recharge based on temperature and precipitation observed at Hyannis and Provincetown from 1931 to 1952. His calculations indicate a mean annual recharge to be about 18.3 inches at Hyannis and about 17 inches at Provincetown (see Table 8 and Figure 1). He estimated that for locations on Cape Cod having a higher mean annual precipitation than Hyannis (42.8 inches/year), the excess precipitation may be added directly to the ground-water recharge. For example, after superimposing the precipitation data observed at Falmouth's Hatchville station onto potential ET data determined at Hyannis, Hatchville, which had 4 more inches of precipitation, showed an estimated recharge of 22 inches per year.

Delaney (1980) estimated ET at Edgartown on Martha's Vineyard to be 23.7 inches annually for the years 1947-1977, yielding an average recharge rate of approximately 22.2 inches per year. Additive recharge from septic outflow was not estimated for this study.

Guswa and LeBlanc (1981) recognized that aquifer recharge on Cape Cod is a combination of natural recharge from precipitation and artificial recharge from sources such as waste-water treatment plants and septic systems. Using a digital three dimensional model to simulate ground water flow in the Cape Cod aquifer they estimated that recharge rates within the study area range from a low of 6 to a high of 22 inches per year.

SEA Consultants (1985) used values taken from the numerical model developed by Guswa and LeBlanc and added artificial recharge rates from septic tanks as 4.3 inches per year for zones 3,4,5,6,7 and 9, and 9 inches per year for zones 1,2 and 8.

Horsley (1983), using the CCPEDC analytical method to determine the zone of contribution on Cape Cod, used a recharge estimate of 13 inches per year based on a study of tritium levels in a glacial drift aquifer (Offer and Larson, 1982). This value was applied to the Cape as a whole. Artificial recharge from septic and waste-water treatment systems was not considered.

The following table summarizes recharge estimates determined from previous investigations on Cape Cod:

Source	Recharge Estimates (inches)	Location
Palmer (1977)	0 - 47.93	Falmouth
Strahler (1972)	17 - 22	Cape Cod
Delaney (1980)	22.2	Martha's Vineyard
Guswa and LeBlanc (1981)	6 - 22	Cape Cod
SEA (1985)	20.67 - 45.67	Barnstable
CCPEDC (1983)	13	Cape Cod

Hydraulic Gradient

The hydraulic gradient of the water table is defined as the change in static head per unit of distance in a given direction (Lohman and others, 1972) and can be determined from a map of water-table elevations. It is an important measurement in calculating a well's zone of contribution. This dimensionless factor not only governs ground-water flow direction but, combined with estimates of aquifer transmissivity and well discharge, helps to define a zone's downgradient and lateral boundaries.

The most comprehensive attempt at mapping water-table elevations on Cape Cod to date is that of LeBlanc and Guswa (1977). Drawing 10 foot contours based on well observations obtained May 23-27, 1976, they identified six freshwater lenses on the Cape Cod peninsula: inner Cape Cod (Cape Cod Canal to the Bass River), middle Cape Cod (Bass River to Orleans), and four smaller lenses on outer Cape Cod (Eastham to Provincetown). Ground water within these lenses moves from points of higher to lower hydraulic head near the shoreline which represents a lateral boundary where ground water is discharged into the sea (Ryan, 1980).

Water-table elevations in Barnstable range from over 60 feet above sea level at the Sandwich-Barnstable town line and Bottom Road to sea level along Cape Cod Bay to the north and Nantucket Sound to the south. Natural groundwater flow directions in the vicinity of public-supply wells are predominantly toward the southeast, but locally may flow toward the north-east, south or southwest in eastern Barnstable or Osterville. Groundwater elevations are particularly affected by the irregular southern coastline of Barnstable, due to the large number of estuaries and tidal inlets.

Water-level elevations are periodically determined at ten established U.S Geological Survey observation wells (Table 9) located throughout Barnstable. These observations, which extend back as early as January, 1958 at one well (A1W 230), indicate that water-table fluctuations range from a low of 3.63 feet in Osterville to a high of 7.67 feet in northeast Barnstable. Changes in water-table elevations occur as a result of several factors: well discharge, evapotranspiration, precipitation and aquifer recharge. Because these factors change over time, multiple water level measurements are needed to identify typical groundwater levels for a particular time of year.

Estimates of hydraulic gradient used by CCPEDC in the vicinity of public-supply wells were determined from the 1976 water-table map of LeBlanc and Guswa. In general, head variations were measured over two to three 10 foot contour intervals in the direction of groundwater flow at the well site. Hydraulic gradients determined by this method range from .0012 at BFD PS3 to .00638 at C/O wells #14 and #15. This information was incorporated along with estimates of well discharge and transmissivity to calculate the downgradient limit of each zone of contribution.

Hydraulic Properties

Specific yield, transmissivity and vertical hydraulic conductivity are the principal hydraulic properties that determine an aquifer's capacity to store, transmit and yield water. The storage term for an unconfined aquifer is specific yield, which is generally defined as "the change that occurs in the amount of water in storage per unit area of unconfined aquifer as the result of a unit change in head "(Lohman and others 1972). Specific yield (Sy) is equivalent to the ratio of the volume of water that saturated rock or soil will yield by gravity drainage to the volume of rock or soil. The usual range of Sy is 0.01 to 0.30. Several workers have compiled representative values of Sy for various unconsolidated materials. Johnson (1967) determined specific yields for common soils which are found in Barnstable, as well as in other areas of Cape Cod:

Material	Diameter, mm.	Specific Yield, Percent
Coarse Gravel	16.0 - 32.0	23
Medium Gravel	8.0 - 16.0	24
Fine Gravel	4.0 - 8.0	25
Coarse Sand	0.5 - 1.0	27
Medium Sand	0.25 - 0.5	28
Fine Sand	0.125- 0.25	23
Silt	0.004- 0.062	8
Clay	< 0.004	3
Till, Predominantly Silt	Variable	6
Till, Predominantly Sand	Variable	16
Till, Predominantly Gravel	Variable	16

The change in storage produced by the filling or draining of aquifer pore space is dependent upon the rate of change of water-table fluctuations, particle size, sorting, time and other factors. Therefore, the values shown in the table above are only an approximate measure of the relation between storage and head in unconfined aquifers (Lohman and others 1972). More consistent estimates of Sy at any one location can be determined by aquifer pump tests and drawdown measurements at observation wells. Most Sy values determined at wells in Barnstable range from 0.20 to 0.29, which are consistent with the sand and gravel materials in which they are screened.

Both CCPEDC and SEA selected uniform values of Sy which were not directly determined from public-supply-well testing, but from secondary sources. According to Horsley (1983), an Sy of 0.25 was taken from Todd (1959, Table 2.2) which summarized data attributed to Poland and others (1949) from their work in California's Sacramento Valley. SEA chose to use the uniform value of 0.20 for its modified numerical model of Barnstable. It is identical to that used by Guswa and LeBlanc (1981) in their digital model of the Cape Cod aquifer.

The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient is defined as transmissivity (Lohman and others, 1972). This property can be visualized as the rate water will move through a vertical strip of the aquifer one foot wide and extending through its saturated thickness under a hydraulic gradient of 100 percent. This rate is commonly measured in terms of square feet per day (ft^2/d) or gallons per day per foot (gpd/ft). An aquifer whose transmissivity is less than about 150 ft^2/d may supply only enough water for small diameter domestic wells. At localities where the transmissivity is greater than about 1000 ft^2/d, sufficient water for municipal, industrial or irrigation wells is usually available.

In an unconfined aquifer, such as that which provides water to Barnstable's public and private wells, transmissivity is the product of the aquifer's horizontal hydraulic conductivity and its saturated thickness (the vertical distance between the water table and a relatively impermeable layer such as thick clay or bedrock). Therefore, an aquifer's ability to transmit water will change in direct proportion to any change in saturated thickness due to natural or man-made water-table fluctuations (see table 9). Values of transmissivity determined by aquifer tests (or computer models) represent estimates based on saturated thicknesses used for a particular time or observation. They may not represent average values. Multiplying the hydraulic conductivity (obtained by an aquifer test) by the minimum known saturated thickness (based on observed water-table elevations) will yield a conservative value of transmissivity at a well site.

Because transmissivity indicates how much water moves through an aquifer it is important for predicting the drawdown of a well at various distances from a pumped well, the drawdown in a well at any time after pumping begins, and the downgradient and lateral boundaries of a well's zone of contribution. Aquifer tests provide insitu measurements of transmissivity

hat are averaged over a large and representative volume. Despite their cost, aquifer tests remain the best method for estimating this important aquifer property.

Most discussions of hydraulic conductivity (K) assume that the geologic materials which store and transmit water are homogeneous and isotropic, implying that the value of K is the same in all directions. However, anisotropy (the condition in which all significant aquifer properties are dependent of direction) is generally the rule in undisturbed, unconsolidated glacial materials. Anisotropy is influenced by the material's environment of deposition, particle size and shape. For example, Palmer (1977), while studying the hydrogeology of glacial outwash deposits in Falmouth, found that hydraulic conductivities in the north south direction of deposition were higher than those which were perpendicular (or east-west) to the direction of stream deposition. Combining a flownet analysis with water-table and saturated thickness maps, he estimated that hydraulic conductivities parallel to the direction of deposition ranged from 140 to 167 feet per day, and the lower transverse values ranged from 62 to 81 feet per day. Such differences are probably due to the linearity of coarse-grained channel deposits laid down by braided streams.

Horizontal layers with relatively low hydraulic conductivity will tend to retard vertical flow (Todd, 1980). In Barnstable, dense, fine-grained till and deposits of glaciolacustine (lakebed) silt and clay are commonly present in beds of sand and gravel. These confining layers control the rate at which recharge moves into the aquifer and vertically toward the well screen during pumping. Extensive deposits of till or glaciolucustine clay can isolate buried aquifers from zones of near-surface, groundwater flow (Freeze and Cherry, 1979). At Barnstable Fire District's well number 3, for example, a 7-foot thick layer of firm blue clay at an elevation of 20 feet below sea level separates upper and lower aquifers consisting of fine to coarse sand and gravel. The well draws water from the lower aquifer at a rate of over 700 gpm. Available well logs for Barnstable Water Company wells ST and SI show that clay layers of varying thickness were penetrated during drilling. These layers, if sufficiently extensive, would tend to restrict contaminant migration to a relatively shallow flow path beneath the ground surface.

Conclusions

1. Municipal planners should make a comprehensive review of all existing information regarding the occurrence, movement and quality of ground water in Barnstable (and adjacent areas of neighboring towns). Such a review will guide the subsequent collection of new data to protect public water supplies. To assist in this review process, the following table, using the town of Barnstable as an example, table summarizes governmental sources and types of information available to town planners. Additional information may be available from geotechnical engineering companies which have performed work in Barnstable under a contractual basis.

Level	Source Number	Government Agency or Firm	Location
Federal	1.	U.S. Geological survey	Boston
	2.	U.S. Environmental Protection Agency	Boston
State	3.	Mass. DEQE - Main Office	Boston
	4.	Mass. DEQE- SE Regional Office	Lakeville
	5.	Mass. Water Resources Commission	Boston
County	6.	Cape Cod Planning and Economic Dev. Comm.	Barnstable
	7.	Barnstable County Health & Env. Dept.	Barnstable
Town	8.	Barnstable Board of Health	Hyannis
	9.	Barnstable Dept. of Public Works	Hyannis
	10.	Barnstable Fire District	Hyannis
	11.	Centerville-Osterville Fire District	Osterville
	12.	Cotuit Fire District	Cotuit
Private	13.	Anderson-Nichols	Boston
	14.	Barnstable Water Company	Hyannis
	15.	Charles A. Maguire & Assoc.	Waltham
	16.	Coffin and Richardson, Inc.	Boston
	17.	Down Cape Engineering	E. Brewster
	18.	IEP, Inc.	Barnstable
	19.	Metcalf & Eddy Inc.	Wakefield
	20.	Schofield Brothers, Inc.	Framingham
	21.	SEA Consultants, Inc.	Cambridge
	22.	Whitman & Howard, Inc.	Wellesley

<u>Types and Source(s) of Information</u>

A. Daily records of public-supply well discharge over the last five years (or existing records for wells less than 5 years old).
Sources: 10,11,12,14

B. Aquifer pump-test data of test wells and water-supply wells.
Sources: 1,3,4,6,9,10,11,12,14,22

C. public-supply and private-well construction data
Sources: 1,3,4,5,6,7,8,9,10,11,12,14

D. Surface and ground-water elevation data.
Sources: 1,6,9,10,11,12,13,14

E. Observations of temperature and precipitation data at Hyannis, Mass.
Sources: 9

F. Location and nature of sources of pollution in Barnstable.
Sources: all

G Location and density of septic and sewage outflow.
Sources: 6,7,8,9

H. Water quality data
Sources: 1,2,3,4,5,6,7,8,9

2. Aquifer pump-test data should be analyzed to determine the aquifer's transmissivity and storage coefficient, the specific capacity of the well and the depth and radius of the pumping well's cone of depression. This information may be obtained by applying one of the following analytical methods. Procedures outlined by these references will give satisfactory results depending on the completeness of the test data:

   a. "A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History," by H. H. Cooper, Jr. and C. E. Jacob, 1946, transactions of the American Geophysical Union, Vol. 27, pp. 526-534, Washington, D.C.

   b. "Analysis of Pumping Test Data From Anisotropic Unconfined Aquifers Considering Delayed Gravity Response," by S. P. Neuman, 1975, Water Resources Research, Vol. 11, No. 2, pp. 329-342, Washington, D.C.

   c. "A Computerized Technique for Estimating the Hydraulic Conductivity of Aquifers from Specific Capacity Data", by K. R. Bradbury and E. R. Rothschild, 1985, Ground Water, Vol. 23, No. 2, pp. 240-254, Worthington, Ohio.

3. Water elevation maps should be drawn from data obtained at both observation and non-pumping, public-supply wells. Maps constructed from data taken at least every three months will reflect the seasonal fluctuations in water-table elevations, flow directions and hydraulic gradients which affect the geometry and orientation of a pumping well's zone of contribution. In areas which have very gradual hydraulic gradients, hydrogeological conditions may require that elevation contours be drawn at one foot intervals to accurately reflect local groundwater flow patterns in the vicinity of and upgradient of public-supply wells.

4. The zone of contribution of the wells should be defined as "Zone II" in accordance with 310 CMR 24.00, Chapter 286, Acts of 1982. The size and orientation of each zone should be determined by the use of the analytical flow model as described by Todd (1980), which requires information about well discharge, aquifer transmissivity, hydraulic gradient and hydrogeologic boundary conditions. Until vertical groundwater gradients in the area between the well and the water-table divide can be determined, the upgradient boundary of the zone of contribution should be .extended to the divide, as a conservative protective measure.

5. In localities having hydrogeologic conditions too complex to be accurately described by an analytical flow model, the use of a finite difference, three dimensional numerical model is recommended. Such a model would be capable of simulating aquifer responses to variable natural and artificial recharge, additional pumping wells and changes in aquifer storage.

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Todd, D. K., 1980, Groundwater hydrology: John Wiley and Sons, Inc., New York, 535 pp.

Table 1. Zone of Contribution Data Used by CCPEDC for Public Supply Wells Barnstable.

Water Company	Well	Well Capacity (Q) (gpm)	60% Q (gpm)	Aquifer Test Transmissivity (gpd/ft)	USGS Model Transmissivity (gpd/ft)	Hydraulic Gradient (i)	Stagnation Point Dist. (feet)
CT	E1	525		45,760			
CT	E2	500		19,800			
CT	E4	500					
TOTAL		1,525	915		28,611*	0.003333	2,200
CT	MAIN	500	300		28,611*	0.0032258	750
CT	E3	300	180		16,269*	0.003333	750
BFD	PS1	600	360	36,030	53,856*	0.003	4,999
BFD	PS1,3	1,250	750				
BFD	PS2	675	405	33,825	38,148*	0.0016667	1,450
BFD	PS3	950	570	85,888	59,466*	0.0012	1,850
BWC	MD1	500		53,120*			
BWC	MD2	500		106,000*			
BWC	MD3	500		35,411*			
BWC	MD4	700		40,920*			
BWC	AIR	1,000		38,540*			
TOTAL		3,200	1,920	54,798**	17,952	0.002	4,000
BWC	SMN	700					
BWC	HYAN	500					
TOTAL		1,200	720		52,360*	0.0019231	1,650
BWC	MEL	1,000					
BWC	MDL	1,600					
TOTAL		2,600	1,560		56,100*	0.0026667	2,400
BWC	ST	500	300		59,840*	0.0024	500
C/O	10	390		38,280			
C/O	AR	700					
C/O	MC	600					
TOTAL		1,690	1,014		54,230*	0.0025641	1,650
C/O	9	500		25,740			
C/O	5	350		17,248			
TOTAL		850	510		55,352*	0.00625	350
C/O	7	340					
C/O	8	340					
C/O	11	290		24,000			
TOTAL		970	582		54,230*	0.0030769	800
C/O	12	300		21,120			
C/O	13	300		27,878			
TOTAL		600	360		61,710*	0.0034884	400
C/O	14	700					
C/O	15	300					
TOTAL		1,000	600		93,500*	0.006383	250
C/O	16	750	450		53,856*	0.0016667	1,150

NOTE: * denotes transmissivity used in zone of contribution calculation. Values of transmissivity for wells in the Mary Dunn wellfield were averaged.
** average transmissivity of Mary Dunn wellfield.

Table 2. Public Supply Wells in Each Zone of Contribution (from SEA Consultants, Inc., 1985).

Zone	Supply Wells Existing	Supply Wells Proposed		Rated or Potential Yield (gpm)[1]	Percent of Total Supply[2]
1	BFD 2			700	
	BW MD4			500	
	BW MD3			500	
	BW MD1			600	
	BW MD2			700	
	BW AIR			1,000	
	BW MEL			900	
	BW MDL 1 & 2			1,400	
		BW MD5		300	
		BW MD6		300	
		BW MD7		300	
		BW MD8		300	
		BW AIR 2		300	
		BW AIR 3		300	
			Total	8,100	30.93
2	BFD 1			350	
	BFD 3			800	
		BFD 4		700	
			Total	1,850	7.06
3	C/O 7 & C/O 8			420	
	C/O 11			350	
	BW ST			500	
	BW SI			700	
	BW HY			600	
		BW ST2		800	
		BW SI2		700	
			Total	4,070	15.54
4	C/O 12			350	
	C/O 13			350	
			Total	700	2.67
5	C/O 5			300	
	C/O 9			425	
			Total	725	2.77
6	C/O AR			500	
	C/O MC			800	
	C/O 10			320	
			Total	1,620	6.19
7	CT E3			275	
			Total	275	1.05
8	CT E2			485	
	CT E1			465	
	CT E4			500	
	C/O 14			700	
	C/O 15			300	
		CT E5		500	
		C/O 17		400	
		C/O 18		500	
		C/O 21		500	
		C/O 22		700	
		C/O 23		700	
		C/O 24		500	
		C/O 25		500	
			Total	6,750	25.77
9	C/O 16			700	
		C/O 19		700	
		C/O 20		700	
			Total	2,100	8.02

Notes: (1) gpm = gallons per minute
(2) Total potential supply = 37,713,600 gallons per day

Table 3. Comparison of Rated Safe Well Yields Used by CCPEDC and SEA Consultants, Inc. for Public-Supply Wells in Barnstable, MA.

Water Company	Well	CCPEDC (gpm)	SEA Consultants, Inc. (gpm)	Difference (gpm)
COTUIT FIRE DIST.	E1	525	465	60
	E2	500	485	15
	E3	300	275	25
	E4	500	500	0
	MAIN	500	---	---
BARN. FIRE DIST.	1	600	350	250
	2	675	700	25
	3	950	700	250
BARN. WATER CO.	MD1	500	600	100
	MD2	500	700	200
	MD3	500	500	0
	MD4	700	500	200
	AIR	1,000	1,000	0
	SIM	700	700	0
	HYAN	500	600	100
	ST	500	500	0
	MEL	1,000	900	100
	MDL	1,600	1,400	200
CENTERVILLE-OSTERVILLE FIRE DISTRICT	MC	600	800	200
	AR	700	500	200
	5	350	300	50
	7	340	420	80
	8	340	420	80
	9	500	425	75
	10	390	320	70
	11	290	350	60
	12	300	350	50
	13	300	350	50
	14	700	700	0
	15	300	300	0
	16	750	700	50

Table 4. Evapotranspiration Estimates for Various Climatological Stations in the Cape Cod Area (from Palmer, 1977).

Station	Chatham*	East Wareham*	Hyannis*	Long Pond+	Provincetown*	South Wellfleet*	Woods Hole*
1965	——	24.17	24.30	24.83	24.82	——	24.96
1966	——	24.39	24.51	24.90	25.06	——	25.59
1967	——	23.19	——	24.21	24.19	24.02	24.54
1968	——	24.80	——	25.64	——	25.22	26.24
1969	——	24.54	25.05	25.37	——	25.35	26.54
1970	——	24.93	——	25.45	——	25.25	26.23
1971	——	25.52	——	25.71	——	25.54	26.37
1972	——	25.25	——	24.31	——	24.63	25.31
1973	24.93	26.18	——	25.03	——	26.25	27.14
1974	24.38	25.08	——	24.70	25.15	25.08	26.37
1975	24.74	25.63	——	25.30	25.89	25.73	——
Normal	——	25.07	——	——	——	——	——

*Calculated from Temperature Data from National Oceanic and Atmospheric Administration, U.S. Environmental Data Service, Climatological Data; New England.

+Calculated from Temperature Data from Records at Long Pond Pumping Station, courtesy of Falmouth Department of Sewer and Water.

Table 5. Annual Precipitation of Various Climatological Stations in the Cape Cod Vicinity (from Palmer, 1977).

		East Wareham*	Hatchville+	Hyannis*	Long Pond**	Provincetown*	South Well-fleet*	Woods Hole*
1965	——	27.82	24.86	27.97	25.15	22.73	——	28.75
1966	——	36.87	36.14	38.91	35.84	41.09	——	40.05
1967	——	52.52	48.48	53.44	48.69	49.32	49.50	53.69
1968	——	44.94	44.34	38.18	41.13	37.64	35.40	45.10
1969	——	53.83	47.91	53.49	45.08	50.11	47.86	50.53
1970	——	44.49	47.86	46.46	43.86	——	40.47	50.47
1971	——	37.46	33.12	36.56	33.21	34.19	30.24	34.32
1972	——	73.84	72.24	61.91	66.40	57.52	57.15	71.31
1973	54.38	51.35	53.65	50.87	53.51	49.25	46.73	57.96
1974	40.50	36.24	36.64	36.03	32.98	33.85	34.32	36.27
Mean	——	45.95	44.52	44.41	42.59	——	——	46.85

*Calculated from Temperature Data from National Oceanic and Atmospheric Administration, U.S. Environmental Data Service, Climatological Data; New England.

**Data courtesy of Falmouth Department of Sewer and Water.

+Data courtesy of Audobon Society, Ashumet Holley Reservation.

Table 6. Calculated Evapotranspiration (in) at Long Pond Pumping Station, Falmouth, MA (from Palmer, 1977).

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1960	0.01	0.25	0.08	1.62	3.27	4.36	5.16	4.61	3.29	2.00	1.13	0.00	25.77
1961	0.00	0.00	0.44	1.37	2.85	4.36	5.30	4.83	3.87	2.23	0.94	0.20	26.38
1962	0.00	0.00	0.58	1.78	3.12	4.39	4.93	4.48	3.24	2.04	0.82	0.02	25.40
1963	0.00	0.00	0.95	1.45	2.95	4.55	5.38	4.68	2.78	2.14	1.18	0.00	25.56
1964	0.00	0.00	0.47	1.25	3.25	4.37	5.09	4.31	3.16	1.92	0.96	0.16	24.93
1965	0.00	0.00	0.20	1.10	3.22	4.22	5.20	4.86	3.19	1.88	0.76	0.20	24.83
1966	0.00	0.00	0.55	1.16	2.71	4.35	5.34	4.78	3.09	1.92	0.99	0.00	24.90
1967	0.16	0.00	0.07	1.08	2.26	4.17	5.38	4.73	3.25	2.18	0.71	0.22	24.21
1968	0.00	0.00	0.50	1.52	3.04	4.13	5.38	4.59	3.39	2.30	0.81	0.00	25.64
1969	0.00	0.00	0.26	1.56	2.93	4.40	4.94	4.96	3.36	1.99	0.97	0.04	25.37
1970	0.00	0.00	0.24	1.39	3.14	4.08	5.56	4.74	3.28	2.01	0.99	0.00	25.45
1971	0.00	0.00	0.29	1.06	2.75	4.41	5.51	4.69	3.46	2.68	0.66	0.19	25.71
1972	0.00	0.00	0.34	0.94	2.93	4.20	5.25	4.67	3.40	1.56	6.67	0.35	24.31
1973	0.00	0.00	0.71	1.49	2.65	4.67	5.36	5.11	3.10	1.91	0.72	0.31	25.03
1974	0.00	0.00	0.35	1.58	2.68	4.14	5.26	4.93	3.27	1.48	0.81	0.21	24.70
1975	0.05	0.00	0.20	0.98	3.08	4.33	5.60	4.74	3.08	2.03	1.17	0.05	25.30
1976	0.00	0.14	0.54	1.84	3.11	4.48	5.24	4.57	3.19	1.61	0.43	0.00	25.16
Mean	0.01	0.02	0.37	1.36	2.94	4.33	5.29	4.72	3.26	1.99	0.87	0.11	25.27

Table 7. Estimated Recharge for Falmouth Area, Cape Cod, Massachusetts (from Palmer, 1977).

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1960	3.15	5.31	2.47	2.68	0.48	-2.33	-0.66	-3.82	2.34	-0.11	1.73	5.39	16.64
1961	2.30	3.99	3.60	2.88	2.50	-2.99	-0.88	0.32	0.55	6.02	3.04	3.11	24.45
1962	4.98	4.42	0.58	2.70	-1.95	1.29	-2.92	-1.58	1.19	6.24	2.85	2.92	20.72
1963	3.76	3.91	3.66	0.94	1.89	-2.94	-2.81	-.209	1.33	-0.49	3.09	2.76	12.63
1964	3.52	4.26	1.57	3.98	-2.63	-3.65	-1.49	-2.64	0.93	2.82	6.05	4.68	11.40
1965	3.11	2.14	1.57	1.69	-1.73	-1.93	-4.39	-1.97	-1.34	0.04	1.36	1.43	0.03
1966	3.52	3.47	1.03	0.55	3.23	-2.93	-3.99	-3.07	2.33	1.19	3.23	2.69	11.24
1967	2.10	2.90	3.69	3.81	6.21	-1.42	-1.63	0.20	-1.18	-0.86	4.33	6.16	24.27
1968	2.71	1.76	9.07	-0.28	0.36	2.51	-4.63	-2.76	-2.50	-0.31	5.75	7.00	18.70
1969	0.87	8.04	4.08	3.30	-1.65	-2.49	-2.99	-3.88	1.22	0.41	6.44	9.15	22.54
1970	1.12	6.29	4.01	1.87	-0.45	0.47	-2.87	1.88	-0.64	1.55	4.94	4.26	22.41
1971	2.96	6.18	3.41	2.14	2.06	-4.13	-4.39	-2.97	-2.91	-0.61	4.26	2.42	7.41
1972	2.74	4.98	5.89	3.98	4.09	6.91	-2.26	-2.89	10.53	2.14	6.20	5.62	47.93
1973	2.05	2.18	2.85	7.04	1.69	-1.93	2.91	-1.37	0.13	2.81	2.22	7.63	27.62
1974	5.07	2.66	2.61	1.65	1.27	-1.05	-3.13	-2.56	0.77	0.61	0.94	3.09	11.94
1975	6.76	3.80	3.72	2.23	-0.34	0.14	-2.25	-0.66	4.61	3.53	6.13	4.48	32.16
1976	5.18	1.98	3.37	-0.67	0.04	-2.25	-0.63	-0.07	-1.00	4.62	1.14	3.19	14.93
Mean	3.29	4.02	3.30	2.38	0.88	-1.10	-2.29	-1.76	0.96	1.74	3.39	4.47	19.24

Table 8. Estimation of Ground-Water Recharge by the Water-Balance Method (from Strahler, 1972).

Hyannis, Mass.*	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
Potential evapo-transpiration, inches	0.0	0.0	0.3	1.3	2.9	4.1	5.3	4.8	3.4	2.1	0.9	0.1	25.2
Precipitation, inches (1931-1952)	4.2	3.5	4.2	3.6	3.1	3.4	2.4	3.7	4.3	3.6	3.3	3.5	42.8
Water surplus	4.2	3.5	3.9	2.3	0.2	-	-	-	0.9	1.5	2.4	3.4	22.3
Water deficit	-	-	-	-	-	0.7	2.9	1.1	-	-	-	-	4.7
						Recharge (22.3 - 4.0)							18.3
Provincetown, Mass.	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
Potential evapo-transpiration, inches	0.00	0.00	0.35	1.26	2.87	4.21	5.35	4.92	3.42	2.13	0.94	0.20	25.69
Precipitation, inches, (1931-52)	4.19	3.03	4.10	3.38	2.55	4.45	2.30	2.86	4.48	3.50	2.98	3.46	40.28
Water surplus	4.19	3.03	3.75	2.12	-	-	-	-	1.06	1.37	2.04	3.44	21.00
Water deficit	-	-	-	-	0.32	0.76	3.05	2.06	-	-	-	-	6.19
							Recharge (21.00 - 4.00)						17.00

* Data for Hyannis rounded to one decimal place

Reference: C.W.Thornthwaite, 1948, An Approach Toward a Rational Classification of Climate Geographical Review, vol.37, pp.55-94.

Data of temperature and precipitation from U.S.W.B.Climatic Summary of United States, Supplement 1931-52, New England, pp.11-23.

Table 9. Maximum Water-Level Fluctuations at U. S. Geological Survey Observation Wells in Barnstable, MA from January, 1958 to July, 1984.

Well	Date of First Observation	Elevation of Ground Surface (feet)	Depth to Water (feet)	Date	Depth to Water (feet)	Date	Difference (feet)
A1W 230	1-31-58	42.5	21.06	5-15-73	26.22	10-25-66	5.16
A1W 247	11-29-62	44.5	20.97	5-25-73	28.64	10-25-66	7.67
A1W 254	10-3-75	47.0	7.72	4-25-83	14.88	12-20-80	7.16
A1W 292	10-2-75	41.4	5.04	6-7-79	9.70	10-23-81	4.66
A1W 294	10-2-75	30.6	9.82	5-20-83	14.73	11-21-81	4.91
A1W 306	10-2-75	53.4	21.80	4-25-83	28.04	1-23-81	6.24
A1W 307	10-3-75	31.2	23.88	7-30-84	27.51	11-24-80	3.63
A1W 313	9-10-75	72.6	43.47	5-23-83	48.05	11-23-81	4.58
A1W 314	2-25-76	91.2	54.92	7-30-84	60.88	11-21-81	6.26
A1W 315	2-25-76	91.2	55.03	7-30-84	61.38	11-21-81	6.35

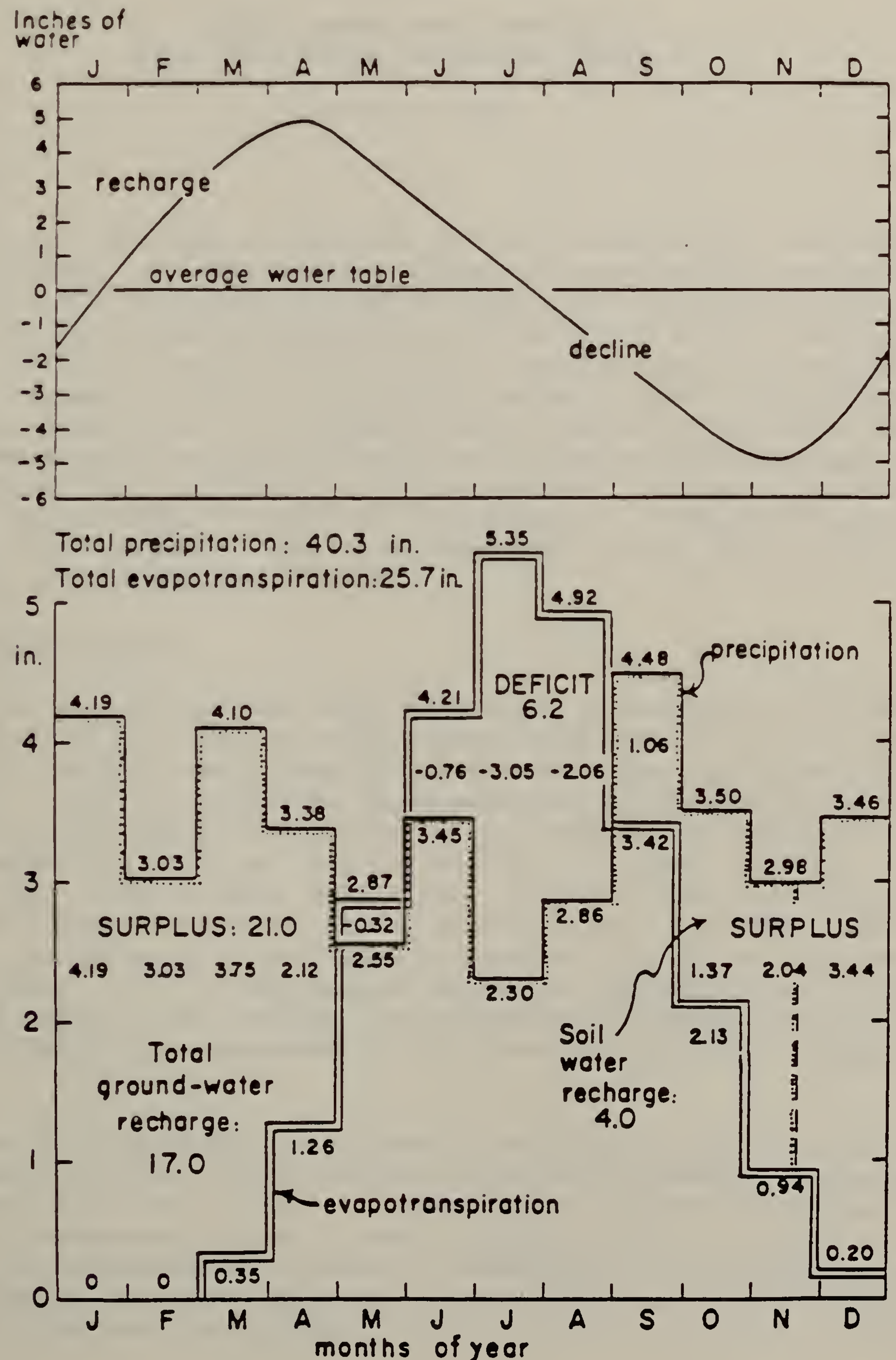

Figure 1. The Water Budget of Provincetown - Based on a Twelve-Year Record, 1931-1952 (from Strahler, 1972).

APPENDIX F

EVALUATION OF APPROACHES TO DETERMINE RECHARGE AREA FOR PUBLIC-SUPPLY WELLS

Aquifer Assessment Committee
Cape Cod Aquifer Management Project

April 3, 1986

Introduction

The Aquifer Assessment Committee has been charged with the evaluation of existing Zone II delineations (zones of contribution around public-supply wells) and the determination of alternative approaches to delineate the Zone II that would be appropriate for the pilot area. The purpose of this report is to outline the salient considerations surrounding these issues, to summarize our evaluation of existing Zone II delineations in the project area, and to recommend future courses of action to meet our charge. The Aquifer Assessment Committee has reviewed the methods used by SEA Consultants and the CCPEDC to estimate Zone II (zone of contribution) about the public-supply wells in Barnstable. It should be noted that Eastham has no community public-water-supply wells and accordingly no existing Zone II delineations.

Background Information

The Zone of Contribution (ZOC) or Zone II as defined in 310 CMR 24.00 is that area of an aquifer which contributes water to a well under the most severe recharge and pumping conditions that can be realistically anticipated. It is bounded by the groundwater divides which result from pumping the well and by the contact of the edge of the aquifer with less permeable materials such as till and bedrock. At some locations, streams and lakes may form recharge boundaries. The delineation of this area is analogous to the delineation of the watershed to a reservoir and it provides the foundation for most quality related groundwater resource planning decisions. It is the area in which the implementation of land-use restrictions should be applied to prevent the contamination of well water. Accordingly the importance of an accurate delineation of Zone II is apparent.

The Zone II delineations performed to date and the alternative methods the Committee will be considering both involve groundwater flow modeling. As described by Walton, 1984: "Modeling is concerned with the dynamic behavior of groundwater systems. Models simulate and are simplified representations of groundwater systems. Modeling is an exercise in systems analysis whereby data and theories concerning the behavior of groundwater systems are organized into models."

"An important aspect of modeling is the proper acknowledgment of the approximate nature of modeling through the clear description of model assumptions and limitations. Adequate documentation and appreciation of assumptions greatly assist the modeler and model user in keeping model result expectations within a realistic perspective."

"Different models require different amounts and types of data. Associated with each level of model sophistication is a data base requirement. Generally, as the model becomes more sophisticated in order to more closely conform to reality, the associated data requirements increase. The modeler is faced with the decision of when the benefits of a more realistic model are outweighed by the difficulty and expense of collecting the data necessary to adequately define such a model."

Groundwater flow models can be separated into two broad categories: analytical models and numerical models. Analytical models are appropriate for the analysis of aquifer test data, simplified aquifer system analysis, and the design of numerical models. They generally include a greater number of simplifying assumptions. They represent the less sophisticated end of the modeling spectrum described above. Numerical models are more adaptable than analytical models. They allow for a more discrete and therefore representative description of the aquifer system. They are appropriate for the analysis of complex aquifer systems. They generally include a lesser number of simplifying assumptions and represent the more sophisticated end of the modeling spectrum.

The ability of a modeling effort (Zone II delineation) to optimize the cost/benefit (model accuracy) relationship, described earlier, is a principal consideration in the choice of the modeling approach. This decision is directly dependent upon the complexity of the hydrogeologic system under consideration (hydrogeologic data availability). The choice of an analytical modeling approach, and the greater number of simplifying assumptions associated with the technique, will generally result in an overestimate of the extent of the Zone II area. This is generally a result of the modeler utilizing more conservative parameter input to compensate for the model's inability to account for complex aquifer interrelationships. The choice of a numerical modeling approach, and the lesser number of simplifying assumptions associated with that technique, will generally result in a more realistic delineation of the Zone II area. This is a result of the model's ability to account for complex aquifer interrelationships such as multiple withdrawal and recharge points, boundary conditions, spatial and directional variation of aquifer properties and recharge, militarily aquifer systems, and partially penetrating wells. This is significant in the Cape Cop pilot area, because in most cases these complex conditions are present.

The importance of a realistic delineation of Zone II becomes apparent when you consider the ramifications of the land use controls that must be placed in this area.

The significance of the relationships described above can best be evaluated by comparing an actual application of both analytical and numerical modeling techniques in the pilot area.

Review of Existing Zone II Delineations

The Committee has reviewed the methods used by SEA Consultants and CCPEDC to estimate Zone II (Zone of Contribution) about the public-supply wells in Barnstable and has concluded that both approaches yield reasonable delineations of the zones. The methods employed are dependent upon analytical models which use the groundwater flow equation or some derivative of it to calculate a groundwater divide (stagnation point). Both methods then use a mass balance approach to circumscribe an area of groundwater recharge or capture which would yield, on average, a quantity of water equal to the assumed withdrawal from the well, and which is bounded on the downgradient side by the stagnation point. The demonstrated applications by SEA and CCPEDC result in similar delineations, but are difficult to compare in detail because different input data were used for recharge rate, aquifer transmissivity, withdrawal rate, and initial water table conditions. It is concluded that either method can yield an approximate delineation of the zone of contribution, but that they cannot be precise It is observed that the analytical methods used for these delineations are based on simplifying assumptions which do not accurately represent nature with its variations and heterogeneity. Therefore, the delineations, while approaching average conditions, can not be expected to accurately reflect the effects of the variations in the real world and therefore must be imprecise on point by point comparison with the field data. It is further concluded that the input data are subject to judgemental variation and perhaps manipulation which can seriously alter the resultant delineations. The most sensitive of these factors are: recharge rate, withdrawal rate, and initial water table conditions. There is a definite need to establish standard criteria for assigning values to these factors and for assigning aquifer transmissivity as well.

Conclusions

Analytical techniques such as those used by SEA Consultants and CCPEDC are useful for preparing initial, simplified estimates of impacts of pumping; however, they are incapable of simulating complex aquifer conditions. The analytical techniques do not account for multiple withdrawal are recharge points, boundary conditions, spatial and directional variation of aquifer properties and recharge, militarily aquifer systems, and partially-penetrating wells. Numerical models, however, can integrate these variables yielding a higher confidence level in model predictions.

Recommendations

1. A demonstration of three-dimensional groundwater modeling is recommended. Ideally, the demonstration would include conditions where the advantages and disadvantages of the modeling approach could be defined and compared with those of the analytical approaches. Opportunities for model verification with past and future water-level data should be utilized. The models should be applied to areas with complex boundary conditions, multiple aquifer systems, multiple withdrawal points, and areally variable recharge, variable aquifer thickness, partial penetration, and changes in aquifer storage. Additional analyses could in-

clude comparison of the area of influence with area (zone) of contribution and determination of the upgradient boundary of the zone of contribution. The subject of data acquisition in terms of requirements and costs should be described. This will allow the determination of the benefits of a more realistic model (more accurate Zone II delineation) relative to the expense of collecting the data necessary to adequately define such a model. Action item - financing is need for a modeling effort of this nature.

2. It is recommended that an evaluation of the existing hydrogeological data base take place in the pilot area. Action item - U.S. EPA Office of Ground Water Protection is currently evaluating this situation; a report to the Aquifer Assessment Committee is being prepared and should be considered supporting documentation for this report.

3. It is recommended that recharge data developed from Thornthwaite calculations be utilized in future delineations for Cape Cod. Sources of this data are Strahler, Palmer, Guswa and Leblanc. No action - data available.

4. It is recommended that transmissivity data be developed from well pumping test data as outlined in the DEQE Guidelines for Public-Supply Wells. Action item - Guidelines are currently being updated.

5. It is recommended that withdrawal data be based on a standard recommended percentage of the well capacity as determined in accordance with the DEQE Guidelines for Public-Supply Wells. Action item - DEQE/DWS to provide Guidelines for percentage.

6. It is recommended that criteria for initializing water-level conditions be developed and the program for data acquisition be upgraded. Action item - Local, state and federal governments have the responsibility to design, create, and monitor an observation well network and publish water-level data. The Aquifer Assessment Group has accepted responsibility for providing detailed guidance for this action.

7. The Zone of Contribution should be referred to as Zone II and determined in accordance with 310 CMR 24.00, Chapter 286, Acts of 1982. No action - regulations exist.

References Cited

Walton, W. C. 1984. Practical Aspects of Ground Water Modelling. National Water Well Association, Worthington, Ohio.

APPENDIX G

QUALITY ASSURANCE FOR GROUNDWATER MODELS THROUGH DOCUMENTATION

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June, 1986

Mathematical groundwater flow and contaminant transport models are tools frequently applied to the analysis of hydrogeological systems. Due to the ramifications of decisions based upon modeling results, quality assurance measures need to be applied to all hydrogeological investigations that involve modeling. The complete documentation of a modeling project is the primary mechanism to insure the quality of the effort.

In order to completely describe the application of a mathematical model to the solution of a hyrogeologic problem, the following outlines the tasks which require documentation. For a more comprehensive treatment of this subject see reference by Van der Heijde (1986).

1. Purpose

   State the purpose, goals and objectives of the modeling effort.

2. Conceptual Model

   Develop and present a conceptual model of the aquifer system and contamination problem of concern (i.e., existing distribution of contaminants and source characteristics). This should include cross-sections and maps at an appropriate scale of the geology and hydrology of the aquifer. Data set strengths and deficiencies should be presented.

3. Data Collection

   Explain how the data were collected, analyzed and interpreted. Exploration methods and data analysis techniques should be presented. The level of confidence in resulting parameter identification should be described.

4. Model Description

   Document the groundwater flow and contaminant transport model (code) utilized. The use of well documented, tested and utilized codes is encouraged. The use of custom or altered codes is discouraged. If an altered code is utilized, it should be thoroughly tested against known solutions. The documentation must include the governing equation(s) being solved.

Explain why the model being utilized was chosen. All simplifying asumptions inherent to the application of the model should be stated and justified, as well as the impact these assumptions may have on model results. A comparison between these assumptions and actual conditions should be made. Describe where model assumptions and actual field conditions do not coincide and how this may affect model results.

5. Assignment of Model Parameters

All initial conditions, boundary conditions, hydraulic and transport parameter values should be defined and the reasons for selecting these conditions justified. The values assigned throughout the modeled area should be presented. The area covered by the model should be presented as an overlay on a topographic base map of appropriate scale, highlighting boundary conditions and hydraulic parameter values.

6. Model Calibration

Model calibration goals and procedures should be presented and discussed. The results of the final calibration run should be presented and analyzed and departure from the calibration targets analyzed. The effects of these departures on the model results should also be discussed. In addition, the overall model water and chemical balance should be evaluated and the salient features of the model scenario (pumpage, recharge, leakage, boundary conditions, etc.) highlighted in this evaluation.

7. Sensitivity Analysis

Model sensitivity analysis should be presented and interpreted. Discuss how well the model meets the purposes, goals and objectives stated in (1) above. Determine what parameters of the model have the greatest influence on the model results. The analysis should focus on those parameters based on the least certain assumptions.

8. Model Validation

Model validation goals and procedures should be presented and discussed. Model validation, or field validation, is defined as the comparison of model results with numerical results, independently derived from laboratory experiments or observations of the environment (Reference No. 1). See Reference No. 1 for a more detailed description of validation procedures.

The results of the final validation run should be presented and analyzed. Important points include departure from the validation targets and the significance of these departures. Present and discuss the overall model water and chemical balance, highlighting salient features of the model scenario (pumpage, recharge, leakage, boundary conditions, etc.).

9. Data Preprocessing and Postprocessing

All preprocessing of model input data must be thoroughly described. Special precautions to avoid data input error must be applied and described. All postprocessing of model output data must be thoroughly described and any computer codes utilized must be documented. Note vertical exaggeration in any computer-generated surface plots or cross-sections.

10. Model Prediction

The model output from all predictive scenarios should be presented and interpreted. Present and discuss the overall model water balance, highlighting salient features of the model scenario (pumpage, recharge, leakage, etc.). Restate the fundamental assumption in the presentation of the model predictions.

11. Model Results

The physical reality of the model should be discussed (i.e. how well does the model represent the physical and chemical processes of the environment being simulated?). Note if the model results support the initial assumptions stated in Section 4 (Model Description).

The model results should be presented in non-technical terms. Preferably, a qualifying answer should be presented: "given conservative values, withing the range of expected variation, the model results show...." ...."given less conservative values within the range of expected variation, the model results show...."

12. Model Records

The modeler should provide/keep on file the following records in digital form:

a. The version of the source code utilized.

b. The final calibration run.

c. All predictive runs.

References:

Van der Heijde, Paul, K.M., 1986, Quality assurance in computer simulations of groundwater contamination: International Groundwater Modeling Center, Holcomb Research Institute, Butler University, Indianapolis, IN 46208.

APPENDIX H

CAPE COD AQUIFER MANAGEMENT PROJECT (CCAMP) RECOMMENDATIONS

WATER SUPPLY PLANNING

December, 1986

Introduction

The importance of water-supply planning is repeatedly made apparent to the Institutions Committee in our examination of the major groundwater protection issues facing Cape Cod. For each town, such as Barnstable with a sophisticated understanding of its water resource and its future water supply needs, there are other towns, particularly those partially or totally dependent on private wells, which have not examined their future needs, nor identified the areas they will need to protect for future well sites. DEQE/DWS needs to conduct an extensive outreach program to provide these towns with technical assistance in planning for water supply development. This outreach effort should be geared particularly to those towns on private wells that will need to develop public supplies soon. DEQE should also expand its current outreach efforts to include technical assistance to towns relating to groundwater protection and the compilation of water-resource-management plans.

The Zone II delineation process and the restriction of certain activities to protect that zone, were pioneered in the Aquifer Land Acquisition Program. The experience gained from this program should be built on and adapted to other water-supply activities at the state level. DEQE/DWS should offer incentives to municipalities to delineate the Zone IIs to their wells and offer guidelines on control mechanisms that might be adapted to protect these areas.

INSTITUTIONS COMMITTEE RECOMMENDATIONS

(PRIORITY RECOMMENDATIONS ARE MARKED WITH AN ASTERISK (*))

Outreach

*1. DEQE/DWS, in conjunction with DEM/DWR, should conduct an analysis of the towns in the state which rely completely (or largely) on private wells to determine which towns will most likely need to develop public water supplies in the future. DWS should design an outreach program targeted to those towns that will reach that point first to provide technical assistance to help them undertake the necessary water-supply-development planning. (See also recommendation 3.)

*2. The State should propose legislation to implement a matching grant program to municipalities identified through the assessment conducted under recommendation #1, to assist them in planning for their transition from private to public water supplies. The grant monies should be used to finance the needed engineering studies to determine what areas should be protected as future well sites.

<u>Background for Recommendations #1 & #2</u>: In examining the state of water-supply planning on Cape Cod and particularly in a town such as Eastham with no public-water supplies, it became clear that much sorely needed water-supply planning is not occurring at the local level. This is especially true in those towns that rely completely on private-water supplies, which do not have knowledgeable water-supply personnel to voice the need for this kind of planning and spur the town into action. Neither is this kind of planning being encouraged actively enough at the state level. DEQE's regional water-supply staff is involved in the new source approval process only after a potential source has been located by the town. Further, there are no state or federal grant programs for water-supply planning such as exist for wastewater planning. State policy stipulates that local water-supply planning should be funded through the rates charged to water consumers but this policy makes no mention of those towns on private wells with no water-related revenues.

If town officials know where they will put a public well, if or when it is needed, then the necessary area can be protected through land-use controls or other mechanisms. Water-supply planning is a crucial base upon which other kinds of planning such as zoning should build. The Construction Grants Program, for example, has a difficult time siting treatment plants in towns that have not identified the areas needed for future water-supply sites. (See CCAMP Recommendations on Groundwater Discharge Permit Program and Construction Grants.) Current development pressures, particularly intense on Cape Cod, are precluding future options as areas with prime water supply potential are developed for other purposes.

<u>COMMENT</u>: DEQE has responded to recommendation #2 by filing a bill for $25,000,000 to provide matching grants to municipalities to identify potential sources of water supply and for $5,000,000 for water-supply master plans.

*3. DEQE/DWS should increase the technical assistance it provides to towns regarding water supply planning and protection through the following means:

a. DEQE/DWS should utilize the new source approval process to educate local officials as to the variety of mechanisms available

to them for protecting the water supply; and to require certain land-use controls or land use bans to be implemented in Zone II; to require evidence of some level of coordination with neighboring communities regarding land uses in Zone IIs which overlap town boundaries; and evidence of coordination between the town's planning board and the water department.

b. DEQE/DWS should initiate an aggressive water supply planning and protection outreach program in the Southeast Region as a pilot program. Having outreach staff in each region is a longer term goal. This outreach should cover both public and private supplies and would provide assistance to towns in compiling comprehensive water resource management plans.

4. DEM should set higher standards for the water resource management plans it requires towns to submit, as these give the towns a good framework for focusing their planning efforts. These town-wide plans also form the basis for the basin wide water resource plans that DEM/DWR develops. The completion of these plans should be required for eligibility for DEQE water supply grant programs. Grant programs included are: the Public Buildings Water Conservation Grants Program, the Leak Detection and Systems Rehabilitation Program, the Drinking Water Facility Construction Grants Program, the Aquifer Land Acquisition Program, the Contamination Correction Program and the Residential Water Conservation Grants Program. In the past, there were not sufficient incentives for towns to put much effort into the water resource management plans. Now, with many water supply grant programs, sufficient incentives exist to expect towns to complete these plans.

5. CCPEDC should investigate sources of funding at the federal and state levels and in the private sector for coordinating a series of workshops and training sessions for local officials on state and federal laws, local powers, water quality monitoring, and land use management for the purposes of water supply protection. DEQE, DPH, DEM, USGS and EPA should make appropriate personnel available to serve on panels or conduct sessions for these workshops.

Public Water Supplies and Zone IIs (ZOCs)

*6. The state should continue to fund and expand the Aquifer Land Acquisition (ALA) program. In addition, the state should provide a matching grant program for delineating the Zone IIs for existing public-supply wells. In addition to funding the necessary hydrological studies, DEQE/DWS could utilize the leverage from the grant program to require that certain land use controls be implemented in the delineated areas (as currently required by the ALA Program).

7. DEQE/DWS, with the assistance of the other divisions, EPA's Office of Groundwater and the Cape Cod Planning and Economic Development Commission (CCPEDC), should provide direct information to municipalities as to what are acceptable activities within Zone II areas and what activities present risks.

8. CCPEDC should investigate the feasibility of instituting a revolving fund that could loan money to towns for the purchase of land to protect water supplies. This would enable towns to step in and tie up land quickly before the price escalates while waiting for a town meeting vote to appropriate money for that purpose.

Protective measures developed through increased information

9. DEQE/DWS should computerize all public supply well water quality data and improve its capabilities for conducting trend analyses. Summaries of these data and any analyses of them should be provided annually to water suppliers, town departments and regional planning agencies. This data automation should be tied into other similar efforts within the Department. This effort could start in the pilot area.

10. DEQE should require more frequent monitoring in public supply wells that show elevated levels of problem contaminants such as nitrates, sodium and synthetic organics. DEQE should develop regulations that specify levels which should trigger additional testing and appropriate sampling schedules.

11. DEQE/DWS should develop risk analysis capabilities to predict the loss of public supplies and advise communities on how to plan for these losses. DEQE should develop a policy that describes appropriate levels of reserve supply and sufficient interconnection to support demand during contamination emergencies.

Institutional

12. DEQE/DWS should examine its current organizational structure and clearly define the responsibilities of the DWS staff in Boston and the regions.

Private Wells

13. DEQE/DWS should develop the present informal private wells installation guidelines into a model bylaw. DWS should undertake an aggressive education campaign to accompany the private well installation guidelines. This outreach should include workshops for local officials on well installation and testing issues.

APPENDIX I

CAPE COD AQUIFER MANAGEMENT PROJECT (CCAMP) RECOMMENDATIONS

ENHANCED GROUNDWATER PROTECTION IN LANDFILL PROGRAMS

December, 1986

Introduction

The following recommendations are the result of the Cape Cod Aquifer Management Project's examination of the current status of groundwater protection from contamination from landfills on Cape Cod. The Project's major emphasis is on improving federal, state and local coordination in protecting the groundwater resource and ensuring that groundwater concerns are at the forefront of all relevant policy considerations. The first issue the Project's Institutions Work Group explored was landfills. We examined current and proposed DEQE regulations and guidelines and spoke extensively with people in different DEQE divisions as well as local landfill operators and town representatives. Because regulations protecting groundwater from landfill leachate are largely a state responsibility, this particular set of recommendations focuses almost exclusively on DEQE programs.

We began our study of landfills at a time when the DEQE landfill program was emerging from a period of several years of dormancy. The legacies of that period, historical siting and operating errors and uncertainty over the outcome of the Norfolk court case involving Proposition 2 1/2 all combine to create a very difficult regulatory situation. Nevertheless, the best protection for groundwater is a strong, comprehensive state landfill program with clearly defined policy goals and regulations and adequate staff resources.

Unfortunately, the current DEQE landfill program does not adequately address groundwater protection. Generally, we found that groundwater considerations were not given sufficient deliberation in program management and decision-making. Further, we observed that basic rules, procedures and definitions relative to groundwater are inconsistent between the landfill program and other groundwater based programs within DEQE. To correct this, we believe it is imperative that the landfill program incorporate groundwater protection considerations in its operating procedures and do so in a manner that provides consistency with groundwater policy and procedures throughout DEQE.

New guidelines are currently being drafted and reviewed by solid waste

personnel and we urge that these be formally adopted and implemented as soon as possible. It is important that groundwater policy concerns be raised at this formative stage of the program rather than addressed when it is too late, in response to a crisis. We hope that our recommendations will provide added impetus and guidance in the Departments efforts to strengthen the groundwater protection afforded by its landfill program. Several of the following recommendations exceed the capabilities of existing DSHW staff; adequate resources must be found to remedy this situation for comprehensive groundwater protection to occur.

We plan to continue to observe the state's landfill programs and monitor the implementation of these recommendations. We will continue to examine landfill policies as they relate to the groundwater discharge permit program, groundwater classification and state sludge and septage policies. As we consider these programs, we will have further recommendations relating to landfills.

Comments on implementation appear after each recommendation.

INSTITUTIONS COMMITTEE RECOMMENDATIONS

PRIORITY RECOMMENDATIONS

1. Impact to public water supplies should be the number one priority of DEQE's landfill management program. Rather than reacting to crises, a prioritized ranking system should be established in writing and implemented. It would be used to drive all landfill activities: siting, plan review, monitoring, inspection, capping, closure and enforcement. The potential impact to groundwater and surface water, the importance of the area's water supplies, soil type, and the geology of the area should be included in the ranking criteria.

2. To ensure a forward-looking posture to groundwater resources protection, the siting sections of the DSHW landfill regulations should incorporate the DWS definition of Zone II recharge areas and <u>prohibit</u> landfills from being sited in Zone II areas of public water supply wells. Existing operating landfills in Zone II areas should be phased out as soon as possible.

3. DEQE should establish a well-defined, comprehensive landfill monitoring program. The objectives and goals of the monitoring program should be stated and the requirements of an acceptable local monitoring program established. The program should be consistent with other DEQE groundwater programs. Established standard procedures should be adhered to by all affected Divisions and should be required of all present landfills that are threatening ground water or are

potential threats, as well as new landfills.

Standard procedures and a minimum acceptable program should be established for the following:

a. Well placement and installation.

b. Sampling protocol and chain of custody procedures.

c. Sampling frequency and parameter selections.

d. Format for the management of the collected data.

e. Statistical analysis of the monitoring data.

f. DEQE review of submitted data.

g. Threshold standards which trigger certain action, including notification of other Divisions and mandatory further monitoring.

h. Oversight/Enforcement of monitoring program.

(More detailed monitoring recommendation are stated on p. 5.)

4. DEQE should assess the potential threat to groundwater from junkyards, stump dumps and abandoned landfills. DEQE should then re-examine its own regulation of these activities based on these findings. DEQE should provide information to the local Boards of Health concerning the degree of threat from these activities and should provide assistance to communities seeking to upgrade their regulation of these sources.

5. The definition of Significant Groundwater Aquifer used by DSHW in their regulations should be consistent with the definition used by DWS and the other Divisions. Significant should be defined as any actual, planned or potential public water supply. A "potential" supply is defined as any aquifer capable of yielding greater than 100 gpm of water.

6. DEQE landfill siting policy should be consistent with DEQE's groundwater protection goals.

7. DEQE policy relating to landfills should reflect that, while landfills may be necessary for certain types of waste (e.g. demolition materials, tree stumps and ash), there are alternative methods of waste disposal such as resource recovery and source reduction which should be considered.

8. DEQE, through the auspices of its Groundwater Protection Committee, should develop an action plan to implement the recommendations made in this report. Specific tasks with milestone and completion dates should be included.

SITE EVALUATION/SITE ASSIGNMENT

9. The site selection stage is crucial for the protection of water supplies; decisions made at this stage usually result in policies and facilities that are long-term and difficult to reverse. The lack of alternative waste disposal methods and the tremendous cost involved in developing any landfill reinforce the continued reliance on land disposal. Thus, long-range planning should be emphasized. Every effort should be made to integrate the BSWD regional planning work with DSHW's landfill program. BSWD's move to DEQE provides a unique opportunity to accomplish this and it should not be wasted.

10. DEQE should establish in writing a clear set of criteria considering potential and actual groundwater use, geology, and soil type, to characterize appropriate and inappropriate sites for landfill location. This site characterization should be stated in the regulations and relayed to local officials and to BSWD staff for use in drafting the regional solid waste plans.

11. The site evaluation required when a site is proposed for use as a landfill must consider impacts beyond the landfill site itself. The DSHW should determine the extent of the study area; it should be large enough so that the landfill's potential effect on any groundwater or surface water supplies must be considered and utilized in decision-making.

12. The DSHW has the responsibility for seeking review and comment from the other Divisions, particularly DWS, on the importance of a groundwater resource that might be affected by the siting and operation of a landfill.

13. The DWS should be given the responsibility for evaluating the importance of the drinking-water potential of a groundwater resource which might be affected by siting and operation of a landfill.

14. When a landfill site is proposed, DEQE should require that the landfill owner submit plans detailing proposed funding of the daily landfill operation, including purchase of intermediate cover material of a very fine grade, provisions for an adequate groundwater monitoring program and for the eventual capping and closure of the landfill.

EXPANSION REQUESTS

15. The BSWD should advise communities when their landfill goes below three years in life expectancy, that they must initiate action to develop a new facility of some sort and put them on an implementation schedule by order, if necessary.

16. Expansion requests need to be considered as fully and seriously as new

sites since so many of the state's present landfills are located in unacceptable sites by current standards. A site evaluation, as described in recommendation #11, should be required.

MONITORING

17. Existing groundwater monitoring handbooks (DWS and DSHW each have one) should be recognized and required to be standard operating procedure. These handbooks are consistent with each other and have already been reviewed. Comprehensive guidelines for monitoring and sampling procedures are being developed by DEQE and will be utilized department wide, once completed.

18. DSHW should review the installation plans for existing monitoring wells on a priority basis using the previously mentioned ranking system. Any of the older wells which may have deteriorated should be closed and replaced, if necessary. Existing landfill monitoring systems should be revised based on this review.

19. DEQE should establish a standard procedure detailing the following aspects of a landfill monitoring program: hydrogeological investigation and field reconnaissance, field verification of flow regime, monitoring well placement, well drilling development techniques, well construction, sampling apparatus, frequency of sampling, sampling protocol, treatment and handling procedures, list of parameters, statistical analysis of data, where data will be sent, and who will be notified once standards are exceeded. DEQE should review the above activities.

20. A detailed protocol for the sampling program and chain of custody should be established when initiating any monitoring program. Information on this protocol should be contained in the DSHW regional files. Any deviations from the established protocol should be clearly noted by the person taking the samples.

21. DWS should provide DSHW with a list of the landfills in Zone II of public-water supplies. DSHW should then request DWS input on groundwater monitoring requirements in these zones. Copies of monitoring results in Zone II should be sent to DWS.

22. DWS should review current monitoring parameters to determine if they are sufficient. DSHW should require monitoring for VOCs on a regular basis.

23. We support DSHW's policy that all new landfills should be required to institute an adequate groundwater monitoring program subject to DEQE approval. DEQE counsel should determine what additional legal authority is necessary, if any, for DEQE to require the initiation of a groundwater-monitoring program (or the enhancement of an existing one) at existing sites other than those applying for expansions.

INSPECTION/ENFORCEMENT

24. The previously mentioned priority ranking system ;should be utilized in guiding the ;inspection and enforcement programs.

25. DEQE should consider increasing its spot checking of high risk landfills on an announcing basis in order to provide a measure of quality control to the inspection reports submitted by local consulting engineers.

26. During the landfill inspection process, the DSHW inspector should review the groundwater monitoring data that has been submitted. The inspector should also make an effort to discover if there has been any groundwater monitoring done in addition to what is specifically required by DEQE. This data should be requested, reviewed and retained in the regional solid waste files.

27. During a landfill inspection, DSHW staff should check that groundwater monitoring wells are capped and locked. On-site landfill personnel should be aware of the location of these wells.

LEACHATE CONTROL

28. We support DSHW's efforts to characterize the leachate from municipal landfills and its effect on groundwater. DEQE should provide the results of this study to the local Boards of Health and the appropriate divisions.

29. All sanitary landfills should implement measures to control, collect, treat and dispose of leachate. The minimum acceptable treatment level and the acceptable disposal methods should be defined.

LANDFILL CAPPING

30. The importance of the threatened groundwater resource should be one of the highest criteria for ranking landfills for eligibility under the landfill capping grant program.

31. Because proper capping is the most effective way to reduce leachate generation after landfill closure, the amount of bonding allowed to a commercial landfill owner should be raised from $5500 per operating acre to a higher figure that will more adequately provide for capping and closure costs.

INTRA-AGENCY COORDINATION

32. The DEQE Groundwater Protection Committee should be given the opportunity to review the criteria for all relevant grant programs in terms of the weight given to groundwater protection.

33. At the present time, the organizational structure and definition of roles and responsibilities for the DEQE landfill program are not clearly defined in one document. A clear description of the entire landfill program and the responsibilities associated with each operating unit needs to be written. This should eliminate any duplication of effort or inconsistencies that might arise as well as catalogue different sources of information relating to landfills. DEQE's landfill program should be consistent with the Governor's solid-waste program once the legislation implementing this passes.

34. As has been previously mentioned, DSHW and the BSWD should cooperate closely. Timetables and deadlines should be coordinated and information shared. The regional solid-waste plans being developed by the BSWD should reflect the DSHW staff's current information and concerns about the environmental sensitivity of certain areas. DSHW and BSWD should each review the guidelines and regulations drafted by the other section.

35. The DSHW landfill program affects other DEQE programs including those of DWS, DWPC and DWWR. New policies and regulations must be reviewed and commented upon by all other appropriate divisions and regions.

FEDERAL

36. EPA Region I should assist DEQE by providing technical assistance and research findings whenever possible. Data and information developed through EPA headquarters should be made available on a regular basis.

LOCAL

37. Landfills on Cape Cod should attempt to establish consistent disposal fee schedules for commercial haulers in order to remove a major incentive for disposing of one town's trash in another town's landfill.

CAPE COD AQUIFER MANAGEMENT PROJECT (CCAMP) RECOMMENDATIONS

PRIVATE WELL PROTECTION

October 20, 1987

Introduction

The community of Eastham was included as one of the two case study towns in the Cape Cod Aquifer Management Project (CCAMP) because there was concern over issues involving groundwater protection in towns dependent on private wells. As a result of CCAMP's examination of the state of private well protection on Cape Cod, we believe that at a minimum, the two types of guidance documents recommended below are crucial in increasing the protection afforded private wells and in protecting public health. These documents are greatly needed by local Boards of Health and private well owners and will require a minimum amount of effort to produce. We strongly urge the implementation of these recommendations in a timely manner.

AQUIFER ASSESSMENT COMMITTEE RECOMMENDATIONS

1. The Barnstable County Health and Environment Department and the Cape Cod Planning and Economic Development Commission should jointly develop an informational brochure for private well owners and local officials. This brochure should draw on and simplify existing material and cover the following topics in an easily understood manner, using graphics where appropriate:

   A. Describe regional hydrology as well as groundwater flow at the lot level and discuss well and septic system siting issues.

   B. Discuss proper disposal practices for household hazardous waste.

   C. Describe how common practices can lead to contamination on one's own property.

   D. Briefly discuss proper well construction; point out common construction problems.

   E. Stress the need for proper well testing. Explain how to interpret well water quality testing results.

   F. Describe proper well abandonment procedures.

2. DEQE should develop a guidance document for local officials regarding private well protection. This could provide the basis for the future development of private well regulations at the state level. This document should include a model bylaw which could be implemented with only minor modifications by municipalities anywhere in the state and a technical appendix. There are a number of different ongoing efforts across the state which address various parts of the private well issue. This guidance document should be comprehensive and should contain specific examples relating to the variety of geologic conditions which are found in Massachusetts. At a minimum, the document should address the following broad categories:

   A. Utilizing groundwater flow and other hydrogeological information to site private wells so as to minimize the potential for groundwater contamination.

   B. Comprehensive initial water quality monitoring and limited ongoing water quality analysis.

   C. Well construction specifications.

   D. Procedures for well abandonment.

APPENDIX K

CAPE COD AQUIFER MANAGEMENT PROJECT (CCAMP) RECOMMENDATIONS

UNDERGROUND STORAGE TANKS

October, 1987

Introduction

The Cape Cod Aquifer Management Project (CCAMP) completed an investigation of the threat to groundwater from underground storage tanks (USTs) on Cape Cod. Focusing particularly on the towns of Barnstable and Eastham and involving numerous interviews with officials at all levels of government, CCAMP gathered data to document the extent of the threat from underground storage tanks and examine the effectiveness of the regulatory controls that are in place. CCAMP developed the following recommendations to fill a number of the gaps that were discovered in the existing regulatory framework and to focus particularly on the most prevalent types of problems in the study area. The major problems observed were the large number of aging, leak-prone tanks and the large number of tanks in close proximity to private- and public-water supplies.

Strong interest in protecting groundwater from leaking underground storage tanks is relatively recent at all levels of government. Accordingly, many of the following recommendations are aimed at effectively meshing the regulations recently passed at the federal, state and local levels and at educating the public and providing technical training to officials who have new responsibilities concerning USTs added to their jobs. The majority of the recommendations suggest measures that can be implemented locally to ensure more complete protection than can be provided by the state regulations alone.

Just one gallon of gasoline can contaminate one million gallons of water. Once a water supply is contaminated, clean up may be prohibitively expensive. It has cost over three million dollars and taken nine years for the South Hollow Wellfield in Truro to resume pumping after contamination by a leaking gas station tank. In a 3,600 acre Zone of Contribution (ZOC) to nine public supply wells in the town of Barnstable, CCAMP found 186 underground storage tanks -- 38% of them 20 years or older. (See Table 1.) There are already six confirmed hazardous release sites in the zone, all from fuel storage areas. The probability of further contamination is high. An EPA contractor has estimated that tanks 20 years and older have a 57% probability of leaking. While this ZOC is more developed than many areas on Cape Cod, the situation is not uncommon Cape wide.

Local governments on Cape Cod have recognized the threats imposed by USTs and most of them have adopted local bylaws or Board of Health regulations to inventory all tanks. When EPA recognized the potential threat posed by USTs, it proposed regulations in 1987 placing primary program responsibility with the States (final regulations will be issued in 1988). In Massachusetts, the Department of Public Safety (DPS) has primary authority over USTs. Key regulations include 527 CMR 9.00 and 502 CMR 3.00. The DPS regulations in turn accord authority for implementation to local Fire Departments (FDs).

FINDINGS

The present state regulations, DPS's 527 CMR 9.00 and DEQE's 310 CMR 30.00, do not go far enough in protecting groundwater from contamination. CCAMP's investigation identified the following shortcomings.

STATE REGULATIONS DO NOT:

- Place all state regulations on All tanks.
- Directly discourage new household fuel tanks from being installed underground.
- Discourage the location of USTs in sensitive areas.
- Encourage the removal of older USTs from the ground.
- Provide a financial source for program implementation.
- Provide sufficient guidance for installation, construction, testing, cleaning and removal.

These shortcomings have led CCAMP to identify the following areas where efforts to improve local control over USTs should be focused.

NEED FOR A LOCAL BYLAW TO PROTECT AND INVENTORY ALL TANKS.

A release of significant size can come from even the smallest tank. Yet, Massachusetts regulations exempt residential and farm gasoline tanks less than 1100 gallons and oil tanks of any size used for consumptive use on premises from notification requirements. The small, lower Cape town of Eastham has a total of 264 tanks averaging 929 gallons and ranging up to 30,000 gallons of capacity per tank that fall into these exempt categories. Only 30 tanks in town, or about 10%, are covered by the state's notification, testing and strict construction standards. Protection must be across the board; towns must ensure that they have identified and adequately controlled all tanks with the potential to contaminate groundwater.

NEED FOR INCREASED LOCAL COORDINATION

A number of towns in Barnstable County have more than one fire district. There are also towns with local regulations granting UST

authority to the Board of Health in addition to fire district responsibilities. This has led to fragmentation, confusion and a lack of leadership.

NEED FOR PUBLIC EDUCATION

Because of the DPS's new UST regulations and the responsibilities they create, there is a strong need for public education as well as training of local officials, particularly concerning tank removals. The large number of absentee homeowners on Cape Cod compounds the public education problem.

CCAMP RECOMMENDATIONS FOR IMPROVED LOCAL CONTROL OVER USTS

1. All Underground Storage Tanks Within Town Should Be Registered.

   An inventory of all tanks including those not covered by the state's notification requirements, existing residential and farm-motor-fuel tanks less than 1100 gallons and all existing heating-oil tanks, should be developed by the town, through a registration process. This would enable health agents to assess every tank in town and identify those that pose the greatest risks (e.g., aging, bare steel tanks) in addition to identifying special problem areas. This information can then be used to set priorities for enforcement and for further attention by the town. Tightness testing requirements may then be placed on tanks of particular concern. On Cape Cod, the Barnstable County Health and Environment Department (BCHED) has been active in providing assistance to towns in structuring and enforcing a tank-tagging program. Under this program, all registered tanks are tagged and no delivery of product occurs to untagged tanks.

2. Each Municipality Should Appoint an UST Coordinator.

   The UST Coordinator should be someone who already works on UST issues and is willing to assume a leadership role. The Board of Selectmen should appoint the coordinator and bestow the necessary authority upon the position to facilitate a cooperative working environment within the town. The major tasks that should be undertaken by the UST Coordinator are:

   - provide a leadership role and spearhead the effort to identify those issues that should be addressed by a local bylaw or ordinance.

   - develop a system for sharing tank data among the local departments who need the information for planning purposes.

   - implement a public education program concerning the dangers from leaking underground-storage tanks.

   - coordinate enforcement of UST program.

3. Initiate a Public Education Program.

Towns need to inform the public of the need for a comprehensive management program for underground storage tanks. Residents should also be aware of the relatively new State program and of any additional town requirements. A special effort to target real estate agents, lending institutions and property managers (especially seasonal property managers) should be initiated. On Cape Cod, with so many absentee homeowners, towns may find it useful to work through property managers and real estate agents to reach individual homeowners. The BCHED's offer to test any homeowner's property for a possible tank leak (free of charge) using a gas chromatograph should be well publicized.

4. Develop a System for UST Data Management.

Towns acting through the Board of Health or Fire Department should maintain a computerized tank inventory by location and age of all underground storage tanks. Periodic data sharing among local boards may be required through a bylaw. The ages of the USTs should be tracked and notices sent to all tank owners whose tanks must undergo State tightness testing in a given year. If there is a requirement for tank removal at a certain age, notices should be sent out for that as well. The towns should utilize existing files for oil-burning permits and incorporate relevant information as part of the database. It should be noted that the BCHED will provide computer management of tank registration and tightness testing data at the County level. This program can manage the redirecting resulting from the town registration and tightness testing requirements.

5. Encourage Additional Permit Review for New Tank Applications.

Current State regulations place primary authority over USTs with the local Fire Districts. This may result in an emphasis on public safety issues at the expense of public health concerns. To ensure that protection of drinking water supplies receives adequate emphasis, the town should require an additional permit review for new tanks that focuses on this issue. This review, conducted by the BOH, or conceivably by the Planning Board, should highlight the proposed location and have the authority to deny permits and set performance standards. A joint review could be conducted informally through a coordinated process initiated by the UST Coordinator or through a bylaw.

6. Discourage the Location of USTs in Proximity to Drinking Water Supplies.

A method for controlling land uses so as to discourage USTs in sensitive areas is required to meet this objective. In towns with public wells, this area corresponds to the Zone of Contribution or a defined Aquifer Protection District. Towns dependent on private wells should identify critical areas based upon housing densities. The most appropriate method of meeting this objective is through zoning.

Several zoning techniques that are particularly well suited include: special use zoning, performance zoning, and incentive zoning.

7. Encourage Replacement of Old Tanks.

It is important to encourage the removal of old tanks and others that may be leak-prone such as bare steel, single-walled tanks. An effort of this sort should concentrate on Zones of Contribution to public supply wells or on highly dense private well clusters. A local bylaw requiring mandatory removal of tanks over 20 years old that do not meet new construction standards is the most direct means of meeting this objective. This should be done in conjunction with a system that tracks tank age and enforces the removal requirement. Another option is passage of a bylaw that requires tightness testing for residential tanks on a similar schedule to that required under State regulations - annually after 20 years. The high cost of annual testing may serve to encourage the removal of tanks greater than twenty years of age. (See Table 2 for cost information.)

8. Discourage Placement of Residential Fuel Oil Tanks Underground.

To aid in detecting leaks, home heating oil tanks and other tanks containing less volatile products should be above ground whenever possible. New residential tanks should be required above ground as a condition placed on development or as a performance standard.

9. Provide Financial Resources to Ensure Program Implementation.

State regulations permit towns to charge up to $200 for each permit. A tank registration fee, permit renewal fee, and tank removal fee are all examples of fees that may be instituted. Towns have been slow to take advantage of this due to the administrative burden of fee collection. However, it is an excellent mechanism for raising money for program implementation. It could also have the advantage of discouraging certain types of tanks from being placed or remaining underground. A permit renewal fee for tanks 20 years old and older, and a registration fee for residential fuel-oil tanks placed below ground are examples of revenue raising mechanisms that also discourage undesirable activities.

CCAMP RECOMMENDATIONS FOR IMPROVEMENTS TO THE STATE UST PROGRAM

10. Construction Requirements In Sole Source Aquifers.

DPS should require specified protection for piping (i.e., double-walled piping or suction pumps) in addition to the strict construction standards which are specified for tanks in sole source aquifers. Waste-oil and fuel-oil tanks should NOT be exempt from the above construction requirements in sole source aquifers. (See 527 CMR 9.16 (1), (3))

11. Expansion of Sole Source Aquifer Construction Requirements to Well Recharge Areas (Zone IIs).

The strict construction standards required for tanks and piping installed in sole-source aquifers should also be required for installations within the Zone IIs of public-supply wells. (See Recommendation #1.) Where the Zone II of a public-supply well has not yet been delineated, the area within a one-half mile radius from the well should be used and the above-mentioned construction requirements should apply within that area. Existing tanks should be put on a compliance schedule to meet these performance standards. DEQE and DPS should jointly initiate this change.

12. Property Transfer Tightness Testing Requirement.

The state should evaluate whether a requirement of UST tightness testing at or around the time of a property transfer should be added to Chapter 21 E.

13. Tank Cleaning and Disposal Policy.

DEQE and DPS should clarify their stance on the disposal of cleaned underground vs. above-ground tanks. There is widespread ignorance on Cape Cod (and presumably elsewhere) of existing tank disposal requirements. DEQE and DPS should develop a clear, workable policy that describes cleaning and removal requirements. These agencies must ensure that adequate disposal locations exist for all types of tanks. DEQE and DPS should then initiate an aggressive outreach campaign targeted at local officials, tank removal and cleaning companies. This could involve pamphlets, tank removal demonstrations and seminars.

14. Tank Cleaning: Increased Control.

DEQE and DPS should then evaluate the need for greater control over the tank cleaning, removal, and installation processes. If still needed after the aggressive education campaign described above, the state should then set standards for tank cleaning and pursue certifying cleaners, removers and installers.

15. Tank Removal Checklist.

DEQE/Division of Hazardous Waste should develop a checklist (modeled after the one currently being used in the Southeast Regional Office) for regional personnel to use during tank removals and inspections. This checklist should also be made available to local fire department staff for their use.

16. Financial Responsibility:

EPA's proposed regulations require that tanks owners demonstrate "financial responsibility". In anticipation of these regulations and

in light of the high costs of site remediation, DEQE and DPS should pursue a state requirement that facility owners obtain adequate insurance (or other guarantee) to cover clean-up costs in case of leaks.

17. Public Education.

DEQE and DPS should assist towns in their efforts to inform the public of the UST problem and existing regulations by providing pamphlets, explanations of state requirements or other educational materials.

CCAMP RECOMMENDATIONS FOR BARNSTABLE COUNTY CONCERNING USTS

18. Public Education.

BCHED should inform all private well owners requesting well tests of the potential threat an underground-storage tank poses to their own water supply. BCHED should urge them to place their underground heating oil tanks above ground.

19. Public Education.

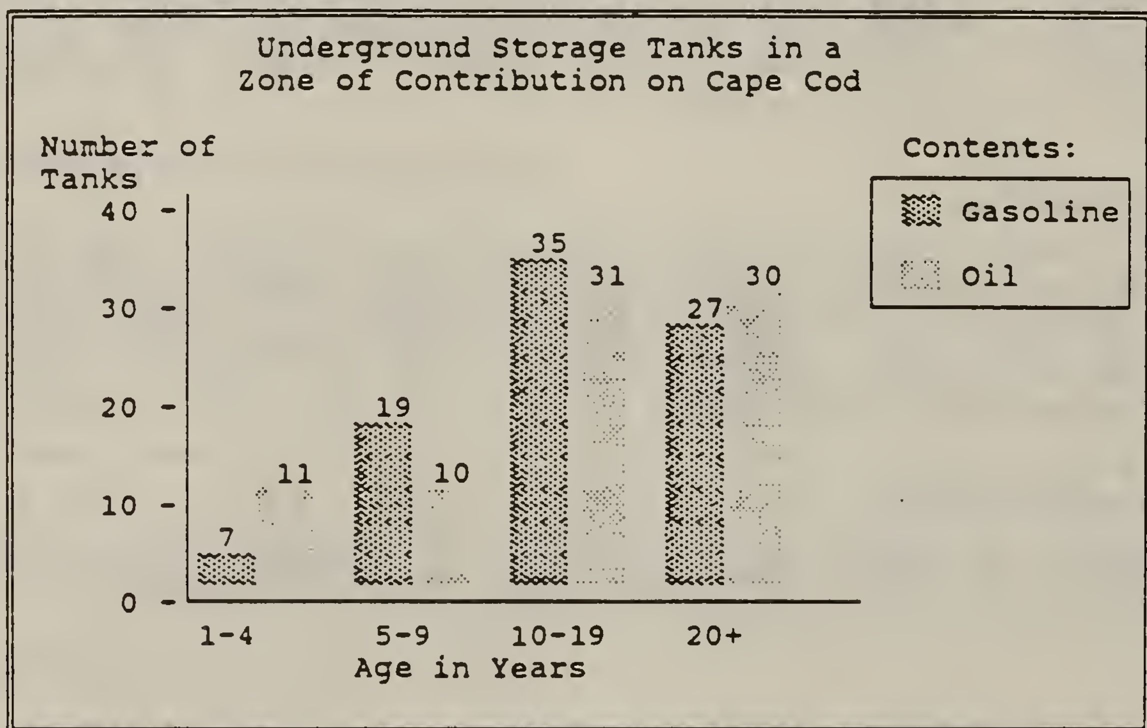
Both BCHED and CCPEDC should utilize local newspapers and other media in a campaign to increase the awareness of Cape Cod residents concerning USTs and should assist towns in developing or procuring relevant educational materials.

20. Technical Assistance.

Both BCHED and CCPEDC should continue to provide technical assistance to communities on UST regulations, management and funding.

Table 1. CCAMP Underground Storage Tank Summary for Barnstable Zone of Contribution No. 1 Study Area, January 1987.

Total Number of Tanks:	186 on 82 sites (13 of these aree residential tanks)
Capacity:	
Total	856,225 gallons
Average Tank Size	4603 gallons
Tanks 20 Years or Older:	71 (38 percent)
Steel Tanks:	122 (65 percent)
Fiberglass Tanks:	32 (17 percent)
Steel Tanks Over 20 Years Old:	50 (27 percent)
Tanks in Use:	116 (62 percent)
Tanks Out of Use or Status Unknown:	70 (38 percent)
ZOC Acreage:	3600 acres



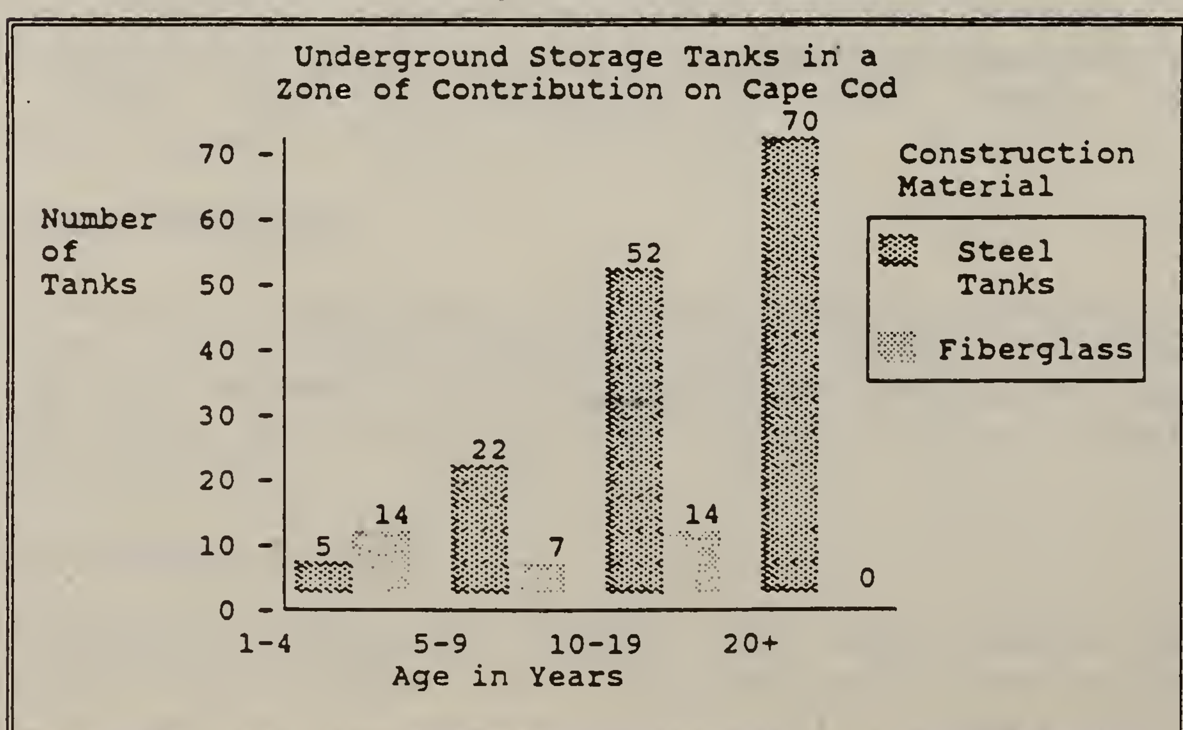


Table 2. Cost of a Local UST Program

To Individual:

Tank Installation	
10,000 gal. double walled fiberglass tank	11.6-13K
10,000 gal. single walled fiberglass tank	4.5-6.5K
Transport and install	5-10K
Between wall tank/pipe sensor system	.3-1.6K
Tank Testing	
Volumetric (change of volume and rate of leak) Generally these are accurate to .05 gal/hr leak	75 - $500
non-volumetric (may not disclose rate of leak)	$500
Removal and Cleanup	
Removal - Excavate - Backfill	$750-$3500
Liquid pumping and removal	$85/hour + $.55-.70/gallon
Cost for removal of tank <1500 gal	$350-500

To Town:

The direct costs of implementation will depend on the scope of the program but will probably increase local salary budget needs by $9000 -25,000 and increase the town's workload by 20-30 percent, approximately one full-time employee.

CAPE COD AQUIFER MANAGEMENT PROJECT (CCAMP) RECOMMENDATIONS

SEPTAGE AND SLUDGE MANAGEMENT

December, 1987

Introduction

Cape Cod has a very serious septage management problem that is jeopardizing water supplies from one end of the peninsula to the other. Progress toward establishing long-term treatment solutions has vacillated between slow, erratic and nonexistent for over a decade, and with the growth rate soaring Capewide, time is running out.

Very little of Cape Cod (less than 10%) is sewered, relying instead on septic systems or cesspools. Approximately 63.8 million gallons of septage is generated from these on-site systems every year. More importantly, only 31% of the volume is treated effectively through co-treatment processes at publicly-owned wastewater facilities in Barnstable, Chatham and Falmouth. The remaining 44 million gallons is discharged to pits and lagoons that provide no treatment prior to returning it to the water table as a highly contaminated organic waste.

There are four major reasons why so little progress has been made in septage management on Cape Cod: (1) The State DEQE has historically given septage management a very low priority resulting in a lack of resources to conduct an active regulatory program; (2) The towns of Cape Cod have generally ignored the obvious threats to their water supplies from pits and lagoons, and have not generated the necessary leadership to confront their problems directly; (3) The inherent controversies and environmental considerations in siting septage treatment facilities; (4) The facilities planning process conducted by town officials, DEQE staff and consulting engineers has in several cases not provided acceptable projects that would result in the construction of public wastewater treatment plants. One outstanding success is the approval of a regional septage facility to serve Orleans, Brewster and Eastham that is presently under construction.

The overall situation has improved lately with the DEQE initiating a stronger enforcement presence geared toward more effective regulation of septage disposal statewide. On Cape Cod, DEQE has been issuing orders for the closure of several illegal pits and lagoons. This in turn is having a salutary effect on town government by forcing increased attention to the matter, and attitudes appear to be changing. Unfortunately, facilities

planning continues to be a laborious process that requires diligence by all those involved to ensure the approval of acceptable projects that will replace the pits and lagoons.

It is understandable that septic treatment projects can get bogged down during the facilities planning process. Septage is a highly concentrated waste, and often the chosen treatment option involves unproven technology that must be carefully evaluated. Also, complex solutions generate controversy at all levels of government, resulting in long delays. Staff of DEQE's Municipal Facilities Branch must give continuous attention to priority septage problems as identified by the Regulatory Branch. As DEQE is first and foremost a regulatory agency, the construction of wastewater treatment plants should be driven primarily by major pollution problems especially those under State cleanup orders. Several existing septage lagoons on the Cape are under such orders and require a concerted effort by all state personnel to resolve the problems. Septage enforcement actions should be at the very top of DEQE's list of enforcement priorities especially if a drinking water supply is threatened.

A Residuals Unit was recently created within DEQE's Regulatory Branch to work on issues involving septage, sludge, grease, etc. CCAMP applauds this as recognition of an area that had been basically disregarded by DEQE. This Unit should be given the appropriate resources to deal with residuals issues in a comprehensive way. In particular, the Department must develop, as soon as possible, a sludge management program in conjunction with septage guidelines.

Local officials on Cape Cod should take more of a leadership role toward developing long-term septage management solutions for their communities. A greater awareness of the septage problem town-wide, and a commitment to better management practices--even if they involve increased costs-must be implemented. Proper regulation of septage haulers, regular septic system maintenance programs, and solutions to peak season pressures, must be initiated. We also encourage each Cape town to develop a fully trained staff to work on Title 5 cases. In addition, an effort toward complementing Title 5 with local supplements, especially those that involve setbacks from septic systems, should be continued.

An intergovernmental management process can succeed if DEQE, CCPEDC, the towns and EPA adopt the following roles. DEQE: strong, visible presence in support of the facilities planning process, and continued consistent enforcement pressure to solve existing septage problems; CCPEDC: Provide the needed forum for bringing state and local officials together, and coordinate the facilities planning process to ensure clear communication. Town: Key officials must establish a leadership role within town and provide a "good faith" effort toward resolving septage

problems; EPA: The regional office should highlight septage management as an area for increased attention, and stress this with DEQE through guidance and funding of program grants, particularly 106, 205(g), 205(j) and wellhead protection.

INSTITUTIONS COMMITTEE RECOMMENDATIONS

SEPTAGE MANAGEMENT

1. DEQE's Division of Water Pollution Control should continue to implement a policy in support of regional septage facilities and increase the visibility of the policy with local communities. Planned regional systems should receive the full attention of the construction grants staff through a "fast track" mechanism that moves the project through the facilities planning process as rapidly as possible. The heart of the "fast track" process should involve staff from the Residuals Unit and staff from the Municipal Facilities Branch working in a complementary fashion to expedite priority projects. Especially important is an active approach that requires working closely with towns and consultants and providing input on siting options, suggested treatment technologies and other critical aspects of the process.

2. Every town on Cape Cod that is not currently involved in planning and implementing a long-range septage disposal solution, should sanction a local task force to commence action. CCPEDC should be responsible for initiating this through the town's Board of Selectmen. An ongoing process should transpire that brings together the town's task force, CCPEDC and appropriate DEQE personnel, all geared toward expediting facilities planning and implementing permanent septage solutions. CCPEDC should promote local citizen participation and awareness of the septage disposal problem (and the issues involved in working toward a solution) by maintaining close contact with local boards, concerned citizens and interest groups.

3. The Residuals Unit, established within DWPC's Regulatory Branch, should be given the resources necessary to implement an effective program. Of particular importance are (1) efforts toward increased coordination with local governments; (2) coordination and support for the Municipal Facilities Branch during facilities planning; (3) development of a policy for managing grease and; (4) a full examination of issues involving the composting of septage sludge, especially those issues involving heavy metals, particularly cadmium.

4. Septage haulers should be licensed by the DEQE on a statewide basis to remediate many of the abuses that are taking place. Unapproved disposal locations; disfunction equipment that leaks and emits odors during transport; use of system additives that endanger groundwater; and other issues must be addressed. In the interim, the towns through their Water Quality Committees or Septage Task Forces should initiate meetings with haulers to better comprehend septage problems

town-wide. Procedures and policies should be developed or modified based on knowledge gained.

TITLE 5

5. The Division of Water Pollution Control should provide on-going technical assistance to towns dealing with local responsibilities under Title 5 of the State Sanitary Code. Because of the rapid turnover of local staff, training in this area must be continuous. The general lack of knowledge at the local level concerning Title 5 demands such an effort. A liaison position, devoted to this on a full time basis, should be established in the Boston office. Each regional office should eventually have its own fully dedicated position.

6. DEQE should actively pursue amending Title 5 to enable effective regulation of contaminants that are not adequately addressed. Additional research needs to be conducted relative to nutrient loading from septic systems and proximity to private wells, wetlands, and surface water bodies. Especially important because of its public health implications, is the relationship of nitrate-nitrogen and private wells. Until this occurs, CCAMP recommends a local Title 5 supplement that is extremely conservative regarding setback distances in the direction of groundwater flow between septic systems and private wells. In those cases where flow cannot be readily determined, the Board of Health should require a substantial buffer in all directions until site specific information is provided. Additionally, the Board of Health should require environmental assessments for all proposed septic systems that may cause environmental or public health problems.

7. Local Boards of Health must become more diligent in implementing Title 5. Because groundwater is such a valuable and limited resource on the Cape, the following actions should be undertaken.

   - Adoption of an ordinance that requires property owners to have inspections made of any septic systems on their property prior to sale. Any danger to the public health presented by a system should be remediated before title changes hands.

   - Boards of Health should ensure that no building permits (issued by the building inspectors) are given until the issuance of applicable state and local permits under Title 5.

   - No construction work permit should be granted for any unsewered establishment discharging an industrial waste until DEQE grants a groundwater discharge permit.

   - Development of a professional staff paid for through the assessment of fees from permit reviews and inspections.

RESEARCH

8. CCPEDC should assess the feasibility of utilizing alternative technologies of septage disposal on Cape Cod. The best technology should be matched with available resources (land, materials), and costs and alternative funding should be reviewed and summarized. Comparable successes and failures of other facilities should also be examined. Thorough analysis of composting, and all relevant issues involved, is particularly important. Any analysis of alternative technologies should also consider whether a Class III designation may be required. Justifying such a designation is a rigorous exercise and this must be factored into any recommended treatment options.

9. EPA's Municipal Facilities Branch should make available all technical information from around the country dealing with co-treatment and separate septage treatment processes. Especially important is information dealing with the organic content of septage, an area that needs increased knowledge so that proper treatment options are selected for Cape Cod projects. Also important is data from locations with similar climatological conditions to Cape Cod relative to land application and composting processes.

10. DWPC should conduct an analysis of the capacity available at those treatment plants receiving sludge, and the generation of sludge from existing and proposed public and private wastewater treatment plants. Conventional knowledge is that sludge capacity is severely lacking and that additional capacity must be developed. DWPC should work with communities to ensure adequate regional capacity for future sludge disposal. New wastewater treatment plants should not be approved until the DEQE is confident that available sludge capacity exists or can be developed for the long-term.

APPENDIX M

CAPE COD AQUIFER MANAGEMENT PROJECT (CCAMP) RECOMMENDATIONS

CONSTRUCTION GRANTS, GROUNDWATER DISCHARGE PERMIT PROGRAM, AND GROUNDWATER CLASSIFICATION

December, 1987

The following are recommendations from the Cape Cod Aquifer Management Group's Institutions Committee concerning the DEQE Groundwater Discharge Permit Program and Groundwater Classification system and EPA's and DEQE's involvement in awarding grants for the construction of wastewater treatment plants. This set of recommendations deals with issues that are particularly crucial for Cape Cod. Domestic wastewater and discharges from commercial establishments form the most prevalent sources of groundwater contamination on Cape Cod. Despite the extreme importance of the programs mentioned above to the protection of the Cape's groundwater resource, the effectiveness of these programs in preventing contamination is limited by national policies, resources, and procedural and communication difficulties.

The Construction Grants program is also important to Cape Cod. Only three of the 15 towns on Cape Cod have proceeded to the construction phase of the 201 grant process. There is tremendous pressure right now to address the sewage disposal needs of the remaining towns before the federal Construction Grants' funds terminate in 1990. However, the facility siting efforts of Construction Grants as well as other programs are hampered in those towns which have not yet designated the areas they will be relying on for future water supplies. Generally, towns have not planned comprehensively for their long-term water supply and wastewater treatment needs. In addition, the federal and state dollars available to communities for wastewater disposal have no counterpart for funding local water supply planning --- planning that should logically come first. The increasingly short time period remaining to conclude the 201 grant makes it imperative that the timing and content of Division of Water Supply input be clarified and formally agreed upon so the grant process can move forward smoothly. CCAMP believes long-term planning and enhanced coordination are critical. If mistakes of the past, such as the siting years ago of Barnstable's wastewater treatment plant on a prime recharge area of the town's aquifer are to be avoided in the future, then an emphasis on both long-term planning and enhanced coordination are particularly crucial to the current, more conservative Construction Grants process.

Further constraint on the Construction Grants program's attempts to locate disposal sites on Cape Cod is the State's Ocean Sanctuaries Act. This Act prohibits new discharges to designated marine sanctuaries including those waters surrounding Cape Cod, forcing the use of facilities that discharge to the ground. CCAMP supports the current examination of this law by the Ocean Sanctuaries Task Force and urges this group to address the problems and necessary trade-offs connected with land disposal

as expeditiously as possible.

Monetary support from the federal government, through the Construction Grants program, has been crucial in allowing many municipalities to take steps to deal comprehensively with their wastewater problems. In the past EPA has been reluctant to support the same advanced levels of treatment for systems discharging to the ground as for those discharging to surface waters. That position has been influenced by an imbalance at the federal level between the incomplete EPA authority over groundwater and the comprehensive EPA control over surface water. EPA's classification of land application as an alternative technology (entitling the applicant to an increased federal funding match) is a further example of the inconsistency of EPA's approach to ground and surface waters. EPA's lower standards for ground discharges, in addition to being inconsistent with EPA's Groundwater Protection Strategy and Cape Cod's status as a sole source aquifer, result in a fragmented approach to the jointly administered Construction Grants program. CCAMP recognizes that this recommendation must be implemented at the national, not state or EPA regional level.

Both the groundwater discharge permit program and the groundwater classification system are relatively new programs. Despite the progress that has been made by the discharge permit program so far, numerous sources of domestic and industrial groundwater discharges remain unregulated. Resources have not been adequate to enable DWPC to regulate all categories of small businesses that may be discharging contaminants directly to septic systems. Though it is not clear what the cumulative effect of these many unregulated discharges is on the ground water quality of Cape Cod, CCAMP believes that a strong groundwater discharge permit program could be a critical factor in the prevention of contamination. CCAMP is carrying out a detailed land use study in one Zone II in the most heavily developed area of Barnstable. This study will enable CCAMP to identify the industries that pose the greatest threat to ground water and to assess the magnitude of the work to be done by DWPC.

INSTITUTIONS COMMITTEE RECOMMENDATIONS

(PRIORITY RECOMMENDATIONS ARE MARKED WITH AN ASTERISK)

CONSTRUCTION GRANTS

1.* EPA should change its policies in response to DEQE's request that it fund the full federal share of Construction Grants projects that are designed to meet a stricter state standard for discharge to the ground. It appears that current EPA operating policies may be sufficiently flexible for EPA to fund at the usual level a project with higher levels of treatment designed to meet a higher state standard

for discharge to the ground in a sole source aquifer with ground and water table conditions such as are found on the Cape.

2. EPA should reconsider its classification by the 201 grants program of land application as an alternative technology. The extra percentage of federal and state funding for plants designed to discharge to the ground creates an imbalance in weighing discharges to ground or to surface water. This may encourage the selection of a ground discharge based on economic rather than environmental considerations. At the present time, this discussion is purely academic for Cape Cod, as a ground discharge is the only option.

3.* EPA and DEQE should require consideration of the development of a public water supply as an alternative to sewering in towns where such a trade-off is relevant in the 201 facilities planning process. Throughout the Construction Grants process, EPA and DEQE should encourage coordination between wastewater treatment and water supply planning.

<u>Background</u>: The majority of Cape towns lack wastewater treatment plants; many have high density zoning with septic systems and private wells resulting in water quality problems. A wastewater treatment plant may be the answer for all or some of these areas. Alternatively, the development of a public water supply may be appropriate for some areas. The current 201 facility planning process discourages the consideration of the latter option. Water supply planning is not included in the consultant's scope of work because it is not an eligible cost. The consultant is merely reimbursed for a summary of existing water supply plans. This is insufficient.

<u>Note</u>: This recommendation will also appear in CCAMP recommendations on Water Supply Planning.

4. DEQE Division of Water Pollution Control and the Division of Water Supply should adopt a formal agreement specifying responsibility for the water supply review of Construction Grants projects, privately funded wastewater treatment facilities, groundwater discharge permits and for DWS input into the groundwater classification process. All Construction Grants projects with groundwater impacts, e.g. land application systems, lagoons, etc., should be reviewed by both DWS and the DWPC groundwater permit program to assess groundwater impacts and to ensure protection for the most beneficial present or future use. Documentation of these reviews should be in writing and maintained as part of the official file. Grant increases or project modifications potentially affecting groundwater should also be in writing and maintained as part of the official file.

<u>Background:</u> The EPA water supply staff review of Construction Grants projects has been delegated to the state. EPA has requested that a formalized agreement specifying responsibility for this re-

view be drafted between the Division of Water Supply and Construction Grants. There already exists a procedure for regional water supply input developed by DWPC; this should be formalized.

GROUNDWATER CLASSIFICATION

5. * DEQE should immediately pursue the inclusion of an anti-degradation provision within the groundwater classification system and/or the banning of certain categorical discharges in vulnerable areas. DEQE should consider requiring all discharges in Zone IIs of existing and identified future well sites to meet anti-degradation standards. A mechanism must then be developed for coordinating anti-degradation designations for surface and ground waters. DEQE should articulate a policy encouraging discharges to that resource which is most easily monitored and observed.

   Background: The ambient quality of the water in a Zone II area may be quite high; the current Class I would allow contamination above the present levels, without exceeding drinking water standards. There is always the possibility of a spill or of the failure of the pollution control system in place resulting in a discharge exceeding Class I standards. The consequences of such an occurrence could be particularly severe in a Zone II, especially for an area with no alternate water supply available. Currently, the only anti-degradation designations allowed are for surface waters, forcing the use of ground discharges in those areas. The state must be allowed the flexibility of requiring stricter standards in critical areas of either surface or ground waters.

6. In designating Class III areas, assurance must be made that future water supply demands can be met without the designated areas. DWPC should request specific input, on a case-by case basis, from the Division of Water Supply as to the future needs of a particular area. (See recommendation #3.)

   Background: This is particularly important because the areas that are suitable for wastewater treatment plant location also tend to be suitable for water supply development. It is important to know the water supply needs of an area before allowing a portion of the aquifer to be contaminated.

7. EPA Region I should work out an agreement with DEQE concerning the relationship between Case III and Class III designations. A formal procedure should be established by both parties coordinating these two procedures and establishing responsibility. Special attention should be provided by EPA's Office of Ground Water Protection in reviewing Class III designations in sole source aquifers.

8. CCAMP supports a stringent review process for the designation of Class III areas and would oppose any efforts to weaken the current

procedures. DWPC should follow the procedures developed by the USGS, USEPA, the consultant community, DEQE and the Cape Cod Planning and Economic Development Commission for working with Class III applicants on their petitions. These procedures (contained in an August 1985 document elaborating the requirements for hydrological studies) describe the timing and content of "scoping sessions" and public hearings to be held for any Class III petition evaluation. CCAMP recommends that these procedures be used by DWPC.

GROUNDWATER DISCHARGE PERMIT PROGRAM.

9. * DEQE should consider the adoption of a reduced threshold combined with a maximum density factor of individual septic systems based on environmental concerns for DWPC review of wastewater discharges. In the meantime, the DEQE Southeast Regional Office should develop a mechanism for assisting local agencies in reviewing large wastewater treatment discharges under 15,000 gpd, the current cutoff, as a pilot assistance project on Cape Cod.

Background: On Cape Cod, most large development projects manage to come in just under the 15,000 gpd limit, thereby avoiding installing a treatment system and monitoring discharges.

10.* DEQE should conduct a thorough review of its policy for holding tanks for industrial waste dischargers in areas with no sewer hookups. DEQE should examine the feasibility of some kind of manifest system (which is highly labor intensive) or some other greater state role in septage hauler licensing as ways of increasing its control over this situation.

Background: On Cape Cod there are currently a handful of holding tanks. The potential exists for there to be many more in the future as the DWPC permit program catches up with different categories of small businesses that may be required to discharge to holding tanks, or for smaller quantities of wastes, to 55 gallon drums. These tanks are pumped out by septage haulers (licensed by the towns) and the wastes are trucked, possibly across several towns, to disposal at a wastewater treatment plant. DEQE approves the disposal location when it approves each holding tank but has no way of knowing if the wastes actually arrive at the designated disposal location. DEQE should think carefully about the implications of this situation in an area such as Cape Cod where there are numerous unsewered areas and long trucking distances between the pumped tanks and the treatment facilities.

11.* The DWPC Groundwater Discharge Permit program should increase the pace of its review of the impacts and need for regulating several categories of small businesses which may be discharging relatively small quantities of harmful wastes to septic systems in unsewered areas. DWPC should develop a systematic policy to prioritize its

examination of commercial categories that are potentially serious sources of localized groundwater contamination.

Background: DWPC has been tackling some of these commercial categories but not all. DWPC has several laundromats under administrative orders; it has also been pursuing particularly troublesome gas stations. New gas stations applying for permits (not all do) are required to use holding tanks. DWPC has not yet been addressing existing gas stations or photo developers or other small businesses.

12. DWPC should undertake a critical investigation of its resources division-wide to ensure that they reflect current concerns, knowledge, and emphasis on groundwater. If a redistribution of resources is warranted, it should be carried out as soon as possible. CCAMP makes this recommendation fully understanding that some staff designations are not transferrable to other programs, but urges DWPC to seek areas of flexibility within those constraints.

13. DWPC should make an aggressive effort to get input from the public on proposed groundwater discharge permits. Rather than simply relying on legal notice, DWPC should notify the relevant town agencies of the proposed permits.

14. DWPC in the regions needs to take a more active role in pursuing violators. This involves carefully reviewing monitoring reports, and following up on projects after permitting through a vigorous inspection effort. Could resources be made available to try out such an effort in the pilot area?

15. DWPC should automate its permit and classification programs as soon as possible to facilitate the review of monitoring results and to improve planning and tracking capabilities as well as to guide enforcement actions. There should be sufficient resources for DEQE to review permit monitoring results adequately as this is crucial to the groundwater discharge permit program.

    Comment: DWPC has begun action on this recommendation with a grant proposal to EPA for computer help.

16. DEQE should require a letter of credit, bond or escrow account for all entities, such as private developers, that are installing wastewater treatment systems.

    Background: A permanent entity must be responsible for the long-term maintenance and replacement of a wastewater treatment facility. The state must be able to ensure the accountability and financial viability of entities installing such systems. Legal staff are currently exploring the available options and DEQE should actively support their efforts.

17. DWPC and DHW should clarify their joint responsibilities concerning the relationships between Class III, Alternate Concentration Limits (ACL's), the Groundwater Discharge Permit program, RCRA licensing, and 21E sites (uncontrolled hazardous waste sites) which require groundwater reclamation work.

    Background: There is considerable overlap between DWPC's and DHW's groundwater - related programs which results in confusion and delay. The sooner responsibilities are clarified, the easier it will be for each Division to work as effectively as possible.

18. EPA should re-examine its definition of regulated wastes under the UIC program to maximize the opportunity for groundwater protection. For optimal groundwater protection, EPA should regulate wastes of concern, not method of disposal.

    Background: Currently, the UIC program covers wastes disposed of in cavities that are deeper than they are wide. The exact same wastes, disposed of in a different manner, are not covered.

APPENDIX N

CAPE COD AQUIFER MANAGEMENT PROJECT (CCAMP) RECOMMENDATIONS

HAZARDOUS MATERIALS USE AND DISPOSAL

December 16, 1987

Introduction

The large and growing number of businesses that generate small quantities of hazardous waste on Cape Cod, coupled with the vulnerability of the aquifer system, make aggressive regulation of the use, storage and disposal of hazardous materials a priority. The heavy emphasis on the remediation of contaminated sites at both the state and federal levels creates concern that efforts geared towards the prevention of future sites may become secondary.

The Cape Cod Aquifer Management Project Institutions Committee examined the hazardous waste issue and gathered data on the implementation of hazardous materials regulations in a wellhead protection area on Cape Cod. The investigation has raised more questions than it has answered, particularly concerning the adequacy of the infrastructure at all levels of government to combat hazardous waste problems. Fully embracing a comprehensive approach to hazardous waste management and resource protection will necessitate broad management changes. As a first step towards this type of change, CCAMP developed the following recommendations aimed at improving groundwater protection by increasing the emphasis in hazardous-waste regulation on prevention, planning, education and coordination among state, regional and local levels.

The new regulatory program for hazardous-waste management is complex and far-reaching. It affects even small businesses and very small generators of hazardous waste. Complying with the regulations is expensive and may necessitate changes in business practices. To encourage compliance, DEQE must look beyond its strictly defined regulatory role and coordinate with DEM/Office of Safe Waste Management (OSWM) to engage in outreach, education and planning. The state should provide technical assistance to small businesses and should encourage and fund regional agencies to sponsor outreach programs, milk runs, and household waste collections. The state should also ensure that attention is focused on waste exchange, source reduction and the creation of economic incentives for waste reduction.

One of the most important lines of defense against improper hazardous materials handling is provided by the on-site presence of inspectors from various local and state programs. The following recommendations highlight the importance of joint DHW/DWPC inspections and increased coordination between local and state inspections.

INSTITUTIONS COMMITTEE RECOMMENDATIONS

1. Joint Hazardous Waste and Groundwater Discharge Permit Program Inspections: SERO Pilot.

DEQE should initiate a pilot program in the Southeast Regional Office (SE-RO) to conduct facility inspections jointly across DHW and DWPC programs. DEQE should develop a workgroup of regional inspectors and representatives from the relevant programs in Boston to work out the specifics as soon as possible. A rough framework and workplan should be developed before large numbers of new employees are hired and before next year's workplans are written.

Discussion: The advantages of a joint inspection program are numerous. They include: more effective and economical use of an inspector's time; a more comprehensive approach to waste disposal; encouraging better overall business management practices; and consistent enforcement across all media of discharge. This approach would foster more efficient and environmentally sound business practices; an operator would think of the various components of his waste stream as a whole and try to reduce the waste generated and then dispose of it properly in a cost-effective manner. Under the joint inspection program, one enforcement notice would be sent noting the violations of the relevant regulations. Any necessary follow-up activity would then be coordinated. CCAMP focused on groundwater related programs but the cross-program inspections could also be set up to include air programs.

Between 1984-1986, when a very rough count was kept, approximately 5 DHW referrals per week were received by DWPC groundwater discharge permit program staff in the Southeast Region. Each referral means that a facility will probably be re-inspected many months later by another SERO staff person. In the meantime, whatever abuses were noted may still be occurring, resulting in the possible discharge of contaminants directly to the ground. The facility operator may have initiated a change of procedure in response to the DHW visit; he may balk at making additional changes at a later date. Having one inspector, or a team of inspectors trained in both DWPC and DHW program policies and responsible for specific sites will result in clearer communication with the facility owner and the local Board of Health. Further, if one inspector were responsible for all the sites in a particular area, he or she would become familiar with the area's Zone IIs and other vulnerable areas such as wetlands.

There are a number of different models that could be employed for setting up a joint inspection program. An individual could be trained to represent all of the relevant programs or a team approach with an information gathering inspector reporting to a team of professionals from the various programs could be utilized. Whatever model is chosen, it should encompass

the utilization of local-health-agent data and knowledge and involve good coordination with local boards on enforcement.

2. <u>Examination of Different Roles in Hazardous Waste Inspections</u>.

In conjunction with the initiation of a joint inspection program in the southeast region, a work group should be established to examine the roles of the DEQE inspectors and local and regional health agents who may be conducting similar inspections under hazardous materials bylaws. This work group should ensure that health agents are aware of DEQE's policies so that businesses will hear a consistent message from both state and local inspectors. Clear communication will permit all levels to present a united front in working on hazardous waste. The work group should determine a way for DEQE personnel to utilize local knowledge, data and referrals. In return, DEQE should provide enforcement assistance to local boards on key cases. Finally, the work group should note the types of follow-up that DEQE may not be able to perform but would like to delegate to local agents. Clarifying the state, local and regional roles in this area will prevent duplication and encourage coordination and innovation as well as result in greater protection to groundwater through a more efficient use of available manpower. The Regional Planning Agencies should assist in coordinating local participation on such a work group.

3. <u>DEQE Regional Staff Responsiveness to Local Health Agent Concerns</u>.

DEQE Regional staff <u>must</u> improve their responsiveness to local health agent referrals and concerns. Many towns employ trained agents and, in general, the sophistication of local boards of health is growing. DEQE must respond promptly to the referrals of these trained observers. In delaying, DEQE risks letting serious sources of contamination go unchecked as well as alienating potential allies and valuable sources of information. To encourage better communication, the regional DEQE offices should encourage towns to meet periodically with at least one representative of the regional office to review priorities and concerns and develop a coordinated enforcement strategy. At this meeting, DEQE should indicate what facilities are its lowest priorities so the Board of Health can plan to cover these. The BOH should then channel further questions and concerns to this regional staff person who will then be responsible for facilitating DEQE regional responses to this town.

4. <u>Ensuring Adequate Local Expertise</u>.

Many towns do not have available resources or expertise to develop their own programs to inspect local businesses using hazardous materials. Such towns should consider jointly hiring appropriately trained inspectors to do this work. The Barnstable County Health and Environment Department (BCHED) should also try to procure funding for regional inspectors specializing in hazardous materials for loan to those towns in need as is currently done with county sanitarians.

Construction Grants, the Groundwater Discharge Permit Program, and Groundwater Classification), this program has been underutilized and understaffed. In examining the regulation of toxic and hazardous materials on Cape Cod, it became apparent once again to CCAMP how crucial this program is for the protection of groundwater. Particularly neglected by this program are discharges from commercial establishments in unsewered areas on Cape Cod. This program must be given adequate resources and enforcement support to fulfill its regulatory role and address these potentially serious sources of contamination.

In an in-depth study of a 3650-acre Zone II for nine public supply wells in Barnstable, CCAMP found 48 businesses that may be discharging illegally to the ground. Out of 141 businesses in the Zone meeting a threshold quantity of toxic or hazardous materials storage requiring compliance with a town bylaw, these 48 do not have EPA manifest notification numbers, do not have tight tanks and are not covered by the groundwater discharge permit program. It is likely that a number of these 48 are discharging industrial wastes to septic systems and should be regulated by DWPC.

The lack of a strong discharge permit program presence on Cape Cod has also led to considerable confusion on the part of local Boards of Health over DEQE policy on floor drains at existing facilities. DEQE/DWPC should address this in a memo or a workshop or by coordinating with the RPA to explain the state policy to local agents.

6. Zone IIs Should Guide Inspection/Enforcement Priorities.

DHW and DWPC should use delineated Zone IIs or proximity to public water-supply wells (within 1/2 mile of well if Zone II has not yet been delineated) to guide inspection and enforcement priorities. Last year, DHW experimented with a number of different approaches to setting these priorities, including type of business, but location relative to a public well was not considered. Targeting facilities within wellhead protection areas should be agency policy and should be practiced by the appropriate programs. It may be useful to insert this into annual program plans.

EPA's RCRA Office should support this method of setting priorities and encourage its use in the Region I states.

7. State and Federal Funding of Innovative Outreach Programs at the Regional Level.

DEQE, DEM and EPA should aggressively encourage innovative outreach programs at the regional level involving education, organized milk runs, registration of waste generators, organized waste collections for households and very small waste generators, waste exchanges and other efforts. This encouragement should include financial support and technical assistance. There should be intensive lobbying for the necessary funds and authority. These agencies should then be responsible for transferring the methods from successful pilot projects to other areas. The RPAs should

actively research and design appropriate outreach programs for their regions. The hazardous waste regulations at the federal and state levels are so far-reaching that these innovative approaches and encouragement are needed to ensure that safe waste management practices are adopted by businesses and homeowners alike.

8. Apply Lessons From Implementation of Barnstable's Bylaw.

CCAMP intensively examined the implementation of Barnstable's Toxic and Hazardous Materials Bylaw, based on a model bylaw developed by CCPEDC and adopted by several towns on Cape Cod. Barnstable's implementation of this bylaw involved an extremely aggressive inspection and education program. Inspections last winter corrected violations at over 60 businesses and found over 2000 gallons of hazardous material improperly stored. The BOH targets certain categories of businesses as well as those within the town's delineated zones of contribution to public supply wells for increased attention. Many of the businesses visited by the health agent are small enough that inspectors from DEQE have not been able to focus on them, thus providing the only enforcement or explanation of environmental regulations these operators may receive. CCAMP has found the implementation of this bylaw to be outstanding and an extremely important tool for groundwater protection in the town. CCPEDC and BCHED should assist in transferring the successful techniques used in Barnstable to other towns.

9. Development of a State Pollution Prevention Program.

DEQE/DHW, DEQE/DSW and DEM/OSWM should increase their commitment to source reduction as well as other innovative methods of waste management such as waste exchanges in order to avoid disposal of waste as a permanent solution. The state should work to make these programs more visible to industries within the state and should build strong incentives into the programs. The state should provide source reduction assistance including education on the potential for environmental damage as a result of improper use, management and disposal of hazardous wastes; and information on improving the management of hazardous substances. The state must also educate homeowners on the proper use and disposal of household products as well as on alternate products.

10. Incentives for Product Substitution.

The EPA should research and implement methods of providing incentives for businesses to utilize product substitution to reduce generation of hazardous wastes. This prevention-oriented approach should be a priority at the federal level.

11. Testing Private Wells for Synthetic Organics in High Risk Areas.

All levels of government have a role to play in ensuring that private wells are tested for synthetic organics in high risk areas where contamination is suspected. On Cape Cod, both the BCHED laboratory and EPA Region I have conducted case study analyses of private wells in specific problem areas

such as downgradient of landfills. These efforts should be continued. CCPEDC and BCHED should cooperate in identifying these high risk areas on Cape Cod and should design a sampling program to test these wells on a periodic basis. EPA Region I Office of Groundwater Protection should investigate providing small-scale funding and technical assistance for such efforts.

12. Removal of Contaminated Soil.

DEQE/DHW must ensure that soil contaminated with petroleum products is removed promptly or awaits removal appropriately contained and covered. CCAMP has heard of instances of contaminated soil that has been dug out of the ground and placed on a tarp awaiting removal for up to six months, during which time the soil may wash away. Clearly, this subverts the intent of any regulation aimed at groundwater protection and the prompt clean-up of contaminated areas. DEQE should promptly develop an interim policy on soil removal and take steps to develop a more permanent, comprehensive solution. Such a solution should involve close coordination with local health agents on implementation. The lack of proper soil disposal and recycling alternatives may be encouraging noncompliance making a continued enforcement presence particularly important.

13. Guide to DEQE Offices.

The DEQE Communications Office should publish a guide to the Boston and Regional Offices noting the appropriate sections (with phone numbers) to contact for particular problems. A brief description of each office's responsibilities should be included. This should be provided to all RPAs, Regional Health Departments, Boards of Health and be available on request for all other municipal offices.

APPENDIX O

CAPE COD AQUIFER MANAGEMENT PROJECT (CCAMP) RECOMMENDATIONS

PESTICIDES

January, 1988

Pesticide contamination of groundwater resources remains largely uncharacterized on Cape Cod. While limited testing of some public and private supply wells, as well as a study of groundwater quality beneath golf courses, have not turned up significant concentrations of pesticides, a data gap exists with respect to this potential source of groundwater quality degradation. Geologic and environmental conditions on Cape Cod indicate the area is conducive to pesticide leaching. A relatively high rate of recharge, combined with sandy soils, shallow depths to water table and localized spots of elevated nitrate-nitrogen in groundwater put the peninsula in a category of vulnerability. Under this scenario, private wells are at greatest risk from many sources of contamination, including pesticides, because they are shallower than public supply wells and draw in less water to provide for dilution.

Fortunately, intensive agricultural practices with liberal pesticide applications are not widespread on Cape Cod. A large number of other commercial applications are prevalent however, including lawn care, small scale agricultural operations and right-of-way maintenance. In order to quantify the threat that pesticide application poses to groundwater quality on Cape Cod, a program of random sampling of private drinking water wells, observation wells and/or monitoring wells is needed. Such a program needs to be supplemented by activity on the state and federal levels to evaluate and restrict those chemicals that could potentially cause unreasonable adverse effects to man and/or the environment.

INSTITUTIONAL COMMITTEE RECOMMENDATIONS

FEDERAL

1. Develop MCLs for all pesticides found in groundwater or with likelihood of leaching to groundwater.

2. Develop analytic methods for pesticides which may be capable of leaching to groundwater.

3. Facilitate information flow to lower levels of government on environmental fates and human health effects of pesticides.
4. Develop information on synergistic health effects of multiple pesticide residues in drinking water.

5. Coordinate environmental fate studies at state and national level.

STATE

6. Rank pesticides in terms of environmental fate and toxicity; review all registrations in terms of this information.

7. Support Massachusetts Dobbin Pesticides Reform Act Bill.

8. Appropriate sufficient funds to conduct environmental fate studies on priority pesticides.

9. Establish private well testing programs through inner-agency task force in especially vulnerable areas. DEQE should provide technical assistance to local boards of health in identifying potential areas of contamination.

10. Develop a multiagency strategy to protect groundwater from pesticide contamination.

11. Compile complete inventory of pesticide products used for various purposes, quantities sold, and the annual use records for various parts of the state.

12. Increase visibility of Department of Food and Agriculture Pesticide Bureau as regulatory enforcement agency through development of regional offices.

13. Research synergistic effects of more than two pesticide compounds in a water supply.

14. Continue interagency task force on pesticides to coordinate response to water supply/public health issues.

15. Provide technical assistance to communities to insure compliance with Massachusetts Pesticide Control Act.

COUNTY

16. Implement program of periodic spot checking of private wells for pesticide chemicals in common use today.

17. Perform pesticide analyses on public supply wells once every three years.

18. Facilitate/coordinate communication between state and local level on pesticide issues.

LOCAL

19. Identify and map all sensitive areas where pesticide use should be restricted or prohibited, including areas of private drinking water supply wells and Zone IIs for public supply wells.

20. Develop communication method to report pesticide incidents to DFA Pesticide Bureau.

APPENDIX P

GROUNDWATER MANAGEMENT APPROACHES IN BARNSTABLE AND EASTHAM

The local role in groundwater protection is absolutely critical because of local control over land-use planning and other important decisions impacting groundwater protection. The following discussion of the groundwater management approaches in Barnstable and Eastham and the needs and opportunities open to these communities illustrates the range of 4 options at the local level.

The land-use study undertaken in a Barnstable wellhead protection area (See Chapter 6) highlights the need for a groundwater-management strategy that focuses on the management of diverse existing sources. CCAMP discovered that many land-use activities have only incomplete regulatory coverage, or completely fall through the "regulatory cracks". Consequently, local officials must create a comprehensive protection program that controls those specific activities. The land-use study also accentuated the point that political boundaries do not coincide with natural-resource boundaries and that intertown coordination is crutial.

Although an intensive study was not performed in Eastham, an inventory and "windshield survey" of commercial activities were undertaken, as was an inventory of state-regulated, underground-storage tanks. The small number of these sources and the large amount of vacant and developable land suggested that Eastham concentrate its efforts in not siting any threatening land-use activities in proximity to present or future water supplies. In order to undertake such an effort, the town must first map its resources and identify future public-supply wells in order to direct threatening land-use activities away from these areas.

Proposed Local Planning Process in Barnstable and Eastham

The investigation in Eastham and Barnstable led CCAMP to document some observations and recommendations for general approaches to groundwater management for any locality. The process, presented in Table 1, is an analysis of how Barnstable's and Eastham's approaches to groundwater management fit into the general framework. It is not designed as a step-by-step map for local planning. It serves primarily as a general methodology. The approach presented is designed to answer three questions: what needs to be protected?; from what does it need to be protected?; and how should it be protected? While the last question generally generates the most interest, the overall effectiveness of any protection measure is critically linked to how well the first two questions are answered. Thus, special attention must focus on developing a strong technical database and on an assessment of needs which will provide the basis for a strong protection program.

What needs to be protected? This first question requires an assessment of the resource in order to identify environmentally sensitive or

Table 1. Local Groundwater Protection Approaches

	QUESTION 1 What to Protect ?		QUESTION 2 Protect from what ?		QUESTION 3 How to Protect ?	
LOCAL PLANNING PROCESS	FORM GROUNDWATER COMMITTEE IDENTIFY FUTURE NEEDS UNDERTAKE WATER SUPPLY PLANS IDENTIFY RESOURCE AREA HYDROGEOLOGIC STUDIES AND DELINEATION		INVENTORY PRESENT AND FUTURE THREATS (within delineated zones of contribution or town-wide) UNDERTAKE LAND USE INVENTORY BUILD-OUT ANALYSIS ANALYZE RESULTS		ASSESS GOVERNMENT CAPABILITY DESIGN LOCAL PROGRAMS TO: FILL IN GAPS IN STATE PROGRAM TO FULLY CONTROL EXISTING THREATS DIRECT FUTURE DEVELOPMENTS OF THREATENING ACTIVITIES AWAY FROM ZONES OF CONTRIBUTION IMPLEMENT AND EDUCATE	
CAPE COD EXAMPLES	BARNSTABLE	EASTHAM	BARNSTABLE	EASTHAM	BARNSTABLE	EASTHAM
ACCOMPLISHMENTS	Delineated ZOC Identified water supply water needs	Preliminary delineation of ZOC	CCAMP landuse inventory Registration of toxic material users (BOH) Registrationof toxic UST's (BOH/FD)	Home heating tank inventory with BCHED	Toxic material user inspections Aadopted UST bylaw (removal after 30 yrs) Strong implementation effort	Increase lot size to protect private wells Passed toxic material bylaw
NEEDS	Examine influence of over-lapping ZOC's Analyze intertown boundary issues Update needs assessment regularly	Undertake form ZOC delineation Examine future supply needs Build out analysis Identify intertown issues	Expand inventory throughout town Identify incompatible future land uses.	Build out analysis Preliminary contaminant inventory using state data Solicit technical aid from CCPEDC/BCHED	Intertown enforcement agreement Intertown coordination Solicit technical aid from CCPEDC/BCHED	Hire staff Implement Title 5 Rezone Implement local bylaw Solicit technical aid from CCPEDC/BCHED

vulnerable areas. This should be undertaken in conjunction with an analysis of community-water needs. Especially important is the delineation of existing and future public well sites and their associated wellhead protection areas. Water-supply planning should also be performed to consider community water demand over time and the alternatives available to meet this demand. A build out analysis as described below could be helpful in this regard.

From what does it need to be protected? Answering this second question requires an assessment of existing and future land-use activities which present potential threats to groundwater in the town. While this is a straightforward exercise, it is often overlooked. It is a critical link in an effective planning process; a process which is not but should be required under Massachusetts statutory law. The inventory step described in question 2 of Table 1 is envisioned to be similar as the one performed in the Barnstable's ZOC #1 (see Chapter 6). It will identify all existing sources of potential pollution. In the build-out analysis step described in question 2, the number and type of future activities which would exist if the town experienced full development under present zoning regulations are mapped. This step requires some technical guidance and understanding of the land-use activities in the area and contaminants generated by these activities. CCAMP's "Guide to Contamination Sources for Wellhead Protection" (available separately from NTIS and described in Chapter 2) can provide this guidance.

How to Protect? When the assessment is complete and results are analyzed, attention must be placed on how to protect the resource. There are numerous alternatives to consider when designing a local protection strategy, including regulatory and nonregulatory measures. With the zones of contribution delineated, a local community should utilize any of these measures to protect specific sensitive areas. Regulatory techniques may include: land-use controls such as zoning and subdivision regulations generally implemented by planning or zoning boards; health regulations such as the local bylaw in Barnstable implemented by the board of health; and police powers such as permitting, standard setting and inspection requirements. Nonregulatory techniques may include: buying sensitive lands as is done in the Massachusetts Aquifer Land Acquisition Program, easement restrictions and public education. An assessment should be made of the relative merits of any one of these measures within a community before a particular approach is embraced.

Specific strategies chosen depend in part on the particular strengths of a town government (i.e. the relative power and influence of the planning board, board of health and conservation commission), the existence of a professional staff, the ability to increase staff work load, and the political ramifications of various protective measures. These factors would lead Eastham and Barnstable to select different protection strategies. While Barnstable has the staff to implement extensive health regulations, Eastham currently does not have the ability to implement similar measures. Additionally, while Barnstable should examine the

capacity for development within the town and phase future growth accordingly, Eastham should probably focus its efforts on utilizing existing land-use controls before creating new programs. This would include rezoning where needed to reflect groundwater protection concerns.

Overcoming Potential Stumbling Blocks

Any approach to local groundwater protection will require some professional staff. While this may appear to be a stumbling block for many communities, there are a variety of innovative alternatives to hiring a full-time person at a large expense. Cooperative agreements with neighboring towns to share a person, or hiring a circuit rider through an Office of Economic and Community Development (EOCD) grant should be investigated.

Obtaining the necessary information to undertake a refined management scheme is essential but also difficult and expensive. Hydrogeologic studies, if done well initially, will not need major updates over time. However, source inventories and water-quality analyses should be ongoing and should be correlated. This data should be shared among all local offices making decisions which could affect groundwater quality.

Finally, public education and implementation of any new protection scheme are essential to its success. Implementation of a regulation after passage is frequently overlooked, but cannot be overemphasized. The Barnstable health regulations are a perfect example of the potential impact of a well implemented bylaw and should be heeded by numerous communities. One means of ensuring implementation of local control measures is to include citizens in the planning process.

APPENDIX Q

CCAMP DOCUMENTS AVAILABLE

September, 1988

(An asterisk indicates documents not included in the final report.)

Except as otherwise noted, all CCAMP documents listed below will be available from the National Technical Information Service (NTIS) after October 1, 1988. Contact NTIS directly at the following address:

National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
(703) 487-4650

<u>General</u>

*1. "Cape Cod Aquifer Management Project Description". November 1985.

2. "Cape Cod Aquifer Management Project: Final Report". 1988. EPA 901/3-88-006. (Final Report includes the following item numbers from this CCAMP list of documents: 6-13; 16, 19-21)

*3. "Cape Cod Aquifer Management Project: Executive Summary". 1988. EPA 901/3-88-003.

*4. "The Cape Cod Aquifer Management Project: A Multi-Agency Approach to Groundwater Protection" by T. Gallagher and S. Nickerson. July 1986. In <u>Proceedings of the Third Annual Eastern Regional Ground Water Conference</u>, NWWA, Springfield, MA. pp. 116-135. Available from your technical library or from the National Water Well Association, 6375 Riverside Drive, Dublin, OH 43017.

*5. "A Resource-Based Approach to Groundwater Protection" by Lee Steppacher and Tara Gallagher. May 1988. <u>Environment</u>, Volume 30(4), pp.4,45. (Available from your technical library).

<u>Institutional Recommendations</u> (Items 6-13 available from NTIS as a package):

6. Cape Cod Aquifer Management Project Recommendations, Enhanced Groundwater Protection in Landfills. August 1986.

7. Cape Cod Aquifer Management Project Recommendations, Construction Grants, Groundwater Discharge Permit Program, and Groundwater Classification. December 1986.

8. Cape Cod Aquifer Management Project Recommendations, Water Supply Planning. December 1986.

9. Cape Cod Aquifer Management Project Recommendations, Underground Storage Tank. October 1987.

10. Cape Cod Aquifer Management Project Recommendations, Septage Management. December 1987.

11. Cape Cod Aquifer Management Project Recommendations, Hazardous Materials Use and Disposal. December 1987.

12. Cape Cod Aquifer Management Project Recommendations, Private Well Protection. October 1987.

13. Cape Cod Aquifer Management Project Recommendations, Pesticide Recommendations. January 1988.

<u>Technical Documents</u>

*14. "A Mass-Balance Nitrate Model for Predicting the Effects of Land Use on Groundwater Quality in Municipal Wellhead Protection Areas" by M. Frimpter, J. Donohue IV, and M. Rapacz. June 1988. 50 pp. (Provides managers with an easily understood methodology and the relevant associated data for application of this formula.).

*15. "Guide to Contamination Sources for Wellhead Protection" by K. Noake. 1988. 75 pp. EPA 901/3-88-004. (This handbook provides detailed information on common land uses and associated contaminants and their environmental fate.).

16. Water-Table Elevations: Eastern Barnstable, Massachusetts, May 11-13, 1987" by D. Heath and E. Mascoop. October 1987.

*17. Locating Available Water-Table Observation Wells". October 1987. Available from Cape Cod Planning and Economic and Development Commission, First District Court House, Barnstable, MA 02630. (Describes methodology to follow for developing a water-table map utilizing existing observation wells.)

*18. "Demonstration of the Use of Three Dimensional Groundwater Flow Modeling and Particle Tracking to Delineate Zones of Contribution to Public Supply Wells, Cape Cod, MA" by USGS. Available May 1, 1990. (Three-year study suggested by CCAMP utilizing numerical modeling in Barnstable and Eastham.). (<u>Available in 1990</u> from the Books and Open-Files Reports Section; Box 25425, Federal Center; Denver, Colorado 80225.)

Items 19-21 will be available as a package from National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161 after October 1, 1988.

19. "Evaluation of Approaches to Determine Recharge Areas for Public Supply Wells " CCAMP Aquifer Assessment Committee. April 1986. (Summarizes the group's evaluation of Zone II delineations in the study area.)

20. "Hydrogeologic Considerations of Zone of Contribution Methods Used by Cape Cod Planning and Economic Development Commission and SEA Consultants, Inc. For Public Supply Wells in Barnstable, Massachusetts". May 1986. (Detailed examination of necessary data for Zone II delineation and discussion of methods of data reduction.)

21. "Quality Assurance of Groundwater Models Through Documentation" by John Donohue, IV. June 1986. (Discusses the necessary documentation which should accompany all groundwater modeling efforts.)

Zone II Inventory

*22. "Cape Cod Aquifer Management Project: Land Use Risks, Impacts on Water Quality, and Methods of Analysis" by Gabrielle Belfit. May 1987. Presented at the American Water Resources Symposium on Monitoring, Modeling and Mediating Water Quality, in Syracuse, N.Y., 14 pp. (Available from your technical library)

*23. "The Management of Toxic and Hazardous Materials in a Zone of Contribution on Cape Cod" by Tara. Gallagher and Lee Steppacher. July 1987. In Proceedings of the FOCUS on Eastern Regional Ground Water Issues: A Conference, July 14-16, 1987, Burlington, Vt. pp. 13-41. (Available from your technical library)

Geographic Information Systems (GIS)

*24. Cape Cod Aquifer Management Project. 1988. "Demonstration of a Geographic Information System for Ground Water Protection. EPA 901/3-88-005.

*25. "Assessing Risk to Water Quality at Public Water Supply Sites, Cape Cod, Massachusetts" by Julio Olimpio, Elizabeth Flynn, and Saiping Tso. Water Resources Investigation Report. In Preparation (Available after January 1, 1989 from the USGS, Books and Open-Files Reports Section, Box 25425, Federal Center, Denver, Colorado 80225.)

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*26. "CCAMP Bibliographies: Publications and Maps". May 1988. Compiled by EPA Region 1 Library. EPA 901/3-88-002.

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